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**The Welsh Engineers' and Founders' Association**

**and**

**The Foundry Trades' Equipment and Supplies Association**

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## *Welding Cast Iron*

It was somewhat of a surprise to us when we discovered that no less than 340 Papers and articles have been written upon the subject of welding cast iron. It is significant that quite a large percentage of the Papers are written by anonymous authors—both foreign as well as British. This information was gleaned from a review of the literature of the subject (up to November 1 last year) by W. Sparagen and G. E. Clausen, printed in the Journal of the American Welding Society. The subject is obviously one which calls for the publication of more data, both of a fundamental character and of practical experience. The inherent difficulty of the latter will persist so long as the great national buying authorities maintain their present attitude towards the reclamation of castings by welding. This unquestionably tends, often quite unnecessarily, to prevent open discussion by all interested parties upon the subject. The review discloses a number of fundamentals which the authors feel they have the right to state after the study of so much literature, and they insist that all grey iron castings should be preheated to 700 deg. C. before gas welding, unless the casting has been machined, when, according to Faulkner, a proper preheating temperature is 535 to 580 deg. C. in order to avoid excessive warping. A reliable flux to be used when using this method of welding is stated to be composed of about 15 per cent. borax, 15 per cent. sodium carbonate and 60 per cent. sodium bicarbonate. The American Welding Society recommends for gas welding cast-iron rods of the following composition:—C, 3.0 to 3.5; Si, 3.0 to 3.5; Mn, 0.5 to 0.75; S, 0.1; and P, 0.5 to 0.7 per cent.

Dealing with electric welding on preheated castings, it is pointed out that some authorities recommend a light peening of the weld, whilst others deprecate such a practice. When cold electric (metallic arc) welding is practised, it is usual to use a covered electrode of mild steel. The materials used for coating electrodes are still enshrouded in mystery, but one authority is quoted as recommending a mixture of 40 to 60 per cent. graphite, 1 per cent. barium chloride, and the balance carborundum, bonding being effected by water glass. Carbon arc welding closely resembles hot metal arc welding, as the preheating temperature and the composition of the filler rods are similar. The flux used is equal parts of sodium carbonate and sodium bicarbonate.

The review, which is of considerable length, deals with the Thermit system and welding by means of non-ferrous fillers. The metallurgical aspect is well studied, and the importance of control with the object of eliminating poor structure and hard spots is emphasised. Two welding symposia have recently been held, but so far as cast iron is concerned, this review is of the most interest. No self-respecting foundry executive would wish to foist a really defective casting upon a customer, but where permission is withheld for salvaging by welding a perfectly serviceable article, a real injustice is being done. The more this subject can be ventilated at scientific assemblies, the sooner will the whole question be rationalised and not left to the discretion of the varying competence of inspectors, who have been known to mistake the mapped surface of a loam-cast casting for cracks!

## *The Spring Meeting*

The recent meeting of the Iron and Steel Institute was chiefly notable for the report on the heterogeneity of steel ingots. The seventh of the series, it earned tributes of admiration from several distinguished Continental metallurgists. Workers in cast iron will come, as steel men have already come, to the conclusion that non-metallic inclusions are their most important study, and the report is largely taken up with the recognition and distribution of these compounds. Something like eighty pages are devoted to the long-awaited report of the Oxygen Panel, dealing with the best method of determining oxygen in its various forms in ferrous materials. Of more direct interest to foundrymen is the section on ingot moulds, over seventy pages in length and containing much valuable tabular and other data, as well as Mr. J. G. Pearce's Paper on the influence of composition and structure on failure of ingot moulds. In this it is made clear that the prevention of failure by cracking and by crazing demand opposing properties, and that the solution is bound to be a compromise. The remaining Paper of foundry interest was that by Mr. J. E. Hurst on the influence of various elements on nitrogen-hardening cast iron. Nitrogen hardening represents one of the most interesting developments of our time. The effects obtained by it could scarcely have been expected, and although it was accomplished over fifteen years ago, they have not yet been satisfactorily explained. Mr. Hurst was the first to apply the process to cast iron, a fact generously acknowledged by the original discoverer, Dr.

(*Concluded on page* 364.)

# The Flow of Metals

Prof. E. N. da C. Andrade, D.Sc., Ph.D., F.R.S., delivered the twenty-seventh annual May lecture before the Institute of Metals last night in the Hall of the Institution of Mechanical Engineers, London. Mr. W. R. Barclay, O.B.E., President of the Institute of Metals, was in the chair.

Flow is most easily observed in the liquid state, but whereas there is a satisfactory theory of gases, and the structure of crystalline solids has been elucidated by the methods of X-ray analysis, very little is known of the actual behaviour of the molecules in the liquid state. It lacks the regularity of the crystal, and the molecules are too close to show the simplicity of behaviour that characterises gases. A liquid has about the same density as a solid, and can be regarded as a solid in which the heat agitation leads to a slow movement of the molecules from their places, a molecule travelling through a distance equal to its diameter after something less than, but approaching a hundred impacts.

Andrade has put forward a theory of liquid viscosity on the basis that the momentum is transmitted from layer to layer, not, as in a gas, by the passage of molecules from one layer into the other, but by instantaneous association of the molecules when they touch, so that at any nearest approach two molecules share their momentum. On this basis a formula can be derived which gives the viscosity of a simple liquid at its melting point, and another which gives the temperature variation of the viscosity.

Molten metals are particularly suitable for experiments designed to throw light on this problem of viscosity, because they constitute liquids which consist of one kind of atom only, and they are not, in general, associated. The viscosity is conveniently measured by sealing up the molten metal in a sphere, suspended *in vacuo*, and observing the damping of the torsional oscillations of the sphere about a vertical axis due to the enclosed liquid. The method has already been used for the alkali metals, and is being extended to other metals.

### The Case of Solids

The flow of solids is, perhaps, at first sight, even more troublesome theoretically than the flow of liquids, for single crystals of metals exhibit plastic flow under very small stresses, whereas a perfect crystal should firstly be strong and secondly be brittle. Again, single crystals of metals show a very marked hardening with flow. The mechanical properties of metal crystals have been elucidated by the work of Polanyi, Schmid, G. I. Taylor and others, and it is now known that the factor which initiates plastic flow is the shear stress in a certain crystal plane and in a certain crystal direction, which can be found by experiment, but there is no general rule, applicable to all crystals, which enables one to decide beforehand what the plane will be, whereas the direction is always the direction in which the atoms are packed most closely. The glide direction seems to be more significant and fundamental than the glide plane.

To explain how it is that metal crystals can flow at all, various workers have suggested, with different detail, that, in the ordinary crystal, places exist where the atoms are out of step, for a small distance, with their immediate neighbours, such regions being called "dislocations" by Taylor. It can be shown that quite a small shear stress will cause such a dislocation to run along, leaving the atoms in the region through which it passes advanced by one. The weakness and the flow of single crystals is explained along these lines. Other internal flaws have been involved to explain the time factor in the flow, and the hardening. It cannot be said that there is any fully satisfactory theory of the flow of single crystals of metals, but a good beginning has been made.

(*Concluded in next column.*)

(*Concluded from previous column.*)

It is, of course, a far step from the single metal crystal to the polycrystalline metal of industry, but we can see that any crystal boundary is likely to stop the propagation of a dislocation, or glide in general, and so will make the metal less weak and less liable to flow. Industry cannot, of course, wait for theory, but the only really satisfactory way to approach the problem of the strength of metals is by way of the single crystal.

# Lightweight Welding Set

In view of the great attention that is now being given to welding methods and processes, special interest attaches to a lightweight a.c. welding set that has been introduced by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, and is manufactured at the company's Witton Engineering Works, Birmingham.

The G.E.C. lightweight welding set illustrated has been specially designed for portability, its weight being reduced to the minimum. The construction, however, provides a unit of ample strength to withstand the severe handling which may be experienced in service. It is suitable for

Fig. 1.—Lightweight Welding Set.

repair work carried out by general repair engineers and for light constructional work where only a medium welding current (up to 100/120 amps.) is required. The welding set consists of a strong base on which the whole of the apparatus is mounted, and a removable cover. Substantial handles are provided, while skids are fitted to facilitate dragging the set over uneven ground.

The set is designed for a current range from 40 to 120 amps., plugs and sockets being provided to give the necessary current adjustment in suitable steps between these limits. When very fine current regulation is required, as for

Fig. 2.—Welding Set with Cover Removed.

welding thin sheet metal, provision is made for varying the reluctance of the magnetic circuit of the choke coil. This enables the welding current to be adjusted in infinitely small steps. The set will operate on single-phase 50-cycle supplies of 190/240 and 380/480 volts. Adjustment to suit the supply voltage can be carried out by altering the primary tapping of the transformer.

# Random Shots

King George VI's visit last week to Greenwich serves as a reminder of a visit paid by an earlier king, George III, to the Arsenal at Woolwich, of which there is an interesting account in "The Gun-founders of England." It reads as follows: "Thursday, July 1st. The Founders are informed that the King will view the Foundery on Tuesday at 9 o'clock, ordered that 22 nine pounders be laid down and that a salute of 21 of them and such mortars and Howitzers and stores as may be requested. That breakfast be got ready and that a 13 inch sea service Mortar be placed in the well and one 10 inch howitzer be got ready."

Please note that the foundry was to be ready by 9 o'clock in the morning and consider the state of travel in the year 1773! The king must have made an early start on his 10-mile journey to Woolwich. Let such Royal enthusiasm be an example to those who are still snoring in their beds at nine o'clock!

Incidentally, the second Saturday in July is still kept as a holiday in the Arsenal, states the same authority, to commemorate his visit.

* * *

Thousands of London's workers are having to "Leggett" to business this week, and whilst it is apt to be inconvenient, it is, nevertheless, good for the health and economical to the purse, unless, of course, the unaccustomed walk makes one feel "like a pint" at the end of the journey.

* * *

Talking of feeling like a pint conjures up a picture of Euston Station on Saturday afternoon. It is evident that the supporters of Preston North End fully expected that they would have reason to celebrate on their return journey, for van after van waiting in the station were seen to be full to the roof with boxes of beer and other similar liquids! At least there was sufficient liquor in which to drown their sorrow.

* * *

Mr. Barrington Hooper introduced a very novel idea into his Harrow Hospital Ball last week. He had all the speeches printed and sealed at the end of each programme, the seal to be broken at the appropriate time. Mr. Hooper aptly described it as "taking the harrow out of the speeches," and indeed it is so often not what the speaker says but the way he says it that is so heartbreaking, especially to those sitting at the tail end of the room. What a daring idea for the Paris conference! What a boon it would prove on these international occasions, when the diners have to try to look intelligent through speeches in half-a-dozen languages.

* * *

Saying of the week: "The difference between political and scientific conferences lies in the fact that the scientists do at least try to understand the other fellow's point of view."—Sir William Larke, at the British Acetylene Luncheon. In fact, they have been known to be so generous to one another's point of view as to settle the matter by the toss of a coin!

"Marksman."

## The Spring Meeting

(*Concluded from page* 363.)

Fry, who has, of course, been mostly concerned with the steels. As far as we are aware, Mr. Hurst's Papers contain practically all the information available on the nitrogen-hardening of cast iron. This last one covers the effects of silicon, phosphorus and manganese, which do not appear to play any vital part in the process. Only two things can be said with confidence; the first is that the successful hardening obtained is concerned with nitrogen, and the second is that it is concerned with the elements aluminium and/or chromium, the use of which seems to be essential to obtain the best results.

# The Iron and Steel Institute

## ANNUAL MEETING AND DINNER IN LONDON

The Annual Meeting of the Iron and Steel Institute was opened last Thursday at the Institution of Civil Engineers, Great George Street, Westminster, London, Sir H. C. H. Carpenter, F.R.S. (retiring President), occupying the chair at the outset.

### Patronage of the Institute

His Majesty King George VI has been graciously pleased to extend his patronage to the Institute. The Council wish to record their deep appreciation of this honour.

### Report of Council

The report states that 333 new members and 70 Associates were elected during the year; twelve Associates were transferred to membership and fifteen members were reinstated. The membership of the Institute at December 31, 1936, was 2,243, an increase of 328 during the year and the largest number yet recorded. The details of the membership are as follow:—Patron, 1; honorary members, 15; life members, 67; ordinary members, 2,042; associates, 118.

The increase in the membership reflects the increased activity in the industry, and is also largely due to the proposals introduced during the year, in accordance with which companies subscribing to the Special Subscription Fund of the Institute are enabled to nominate members of their staffs, who are qualified, to join the Institute, and to set the amount of their entrance fees and first year's subscription (but not those for subsequent years) against the amount of the companies' subscriptions to the Fund. At the end of the first year members and Associates nominated in this way become personally liable for their subscriptions, but companies are enabled to nominate additional members of their staffs to join the Institute as long as they subscribe.

The Council desire to place on record their sincere regret at the death of the Rt. Hon. Lord Invernairn of Strathnairn, a Past-President, and of Prof. H. Le Chatelier, Honorary Vice-President. Lord Invernairn was a very old member of the Institute, his election having taken place in 1879. He became a member of Council in 1891 and a Vice-President in 1905. In 1912 he became the honorary treasurer, and in 1916 was elected President. In 1918 he was awarded the Bessemer Gold Medal. Prof. Henry Le Chatelier, famous as a physicist, chemist and engineer, became a member of the Iron and Steel Institute in 1904. The Bessemer Gold Medal was conferred upon him in 1911. In 1924 he was elected an Honorary Vice-President. The report also refers to, amongst others, the death of Mr. W. C. Mitchell, who had joined the Institute in 1903, and was a life member.

The statement of accounts shows that the ordinary income of the general fund was £10,972 0s. 2d., an increase of £2,183 3s. 5d. over the corresponding figure for the previous year, and the expenditure was £12,855 13s. 3d., which represents an increase of £2,134 4s. 10d.; the excess of expenditure over income was, therefore, £1,883 13s. 1d., or £48 18s. 7d. less than in the previous year. The increase in the income of the Institute during the year was largely due to the welcome increase in the membership, and of this new members nominated by companies formed a large proportion.

*Changes on the Council.*—As Mr. Hutchinson had expressed the wish to retain the presidency for not longer than one year, the Council have nominated the Rt. Hon. the Earl of Dudley, M.C., to succeed him in May, 1938. Mr. Henry C. Bond expressed his desire to retire from the Council, owing to the severance of his connection with the industry, and Mr. E. J. Fox was elected a member of Council in his place; Mr. Bond was nominated an Honorary Vice-President. Mr. T. G. Bamford succeeded Mr. J. T. Wright as honorary member of Council on being elected President of the Staffordshire Iron and Steel Institute, Mr. W. B. Baxter succeeded Mr. G. W. D. Townsend on his election to the presidency of the Lincolnshire Iron and Steel Institute, and Mr. F. W. Bowden succeeded Mr. F. Bainbridge as President of the Cleveland Institution of Engineers.

MR. ALFRED HUTCHISON, M.A.
*(President of the Iron and Steel Institute).*

In accordance with By-law 10, the names of the following Vice-Presidents and members of Council were announced at the Autumn Meeting as being due to retire at the Annual Meeting in 1937:—*Vice-Presidents.*—Mr. C. E. Lloyd; Dr. W. H. Hatfield, F.R.S.; Sir William Larke, K.B.E. *Members of Council.*—Mr. E. J. George; Mr. J. S. Hollings; Mr. W. J. Brooke; Mr. F. Clements; Mr. J. E. James. No other members having been nominated up to one month previous to the Annual Meeting, the retiring members are presented for re-election.

Since the close of the year Dr. Fritz Springorum and Dr. Ernest Poensgen have been nominated Honorary Vice-Presidents, and Dr. O. Petersen an honorary member of the Institute. The Hon. Roland D. Kitson, D.S.O., hitherto an ordinary member of Council, has been nominated an Honorary Vice-President, and Prof. W. A. Bone, F.R.S., hitherto an ordinary member, has been nominated an honorary member of the Institute.

### Andrew Carnegie Research Scholarships

Grants were made by the Council in 1936 to the following candidates:—

P. T. CARTER (Armstrong College, Newcastle-upon-Tyne).—£50, for an investigation of the properties of graphite.

H. A. MILEY (The University, Cambridge).—£100, in aid of a research on the thickness of thin oxide films on iron and the law of growth at ordinary temperatures.

W. HOOK (Armstrong College, Newcastle-upon-Tyne).—£50, to study the pyrolysis of organic compounds with a view to the determination of factors which favour graphite formation. (Second grant.)

G. T. RICHARDSON (The University, Leeds).—£50, in aid of a research on the influence of varying atmospheres on steels. (Second grant.)

J. B. VICKERS (The University, Sheffield).—£75, in aid of work on the determination of oxygen in steel. (Second grant.)

T. RAINE (The University, Sheffield).—£75, in aid of work on the determination of oxygen in steel. (Third grant.)

G M. DYSON (Loughborough College).—£50, in aid of a research on the adsorption of gases by cast iron and steel and their diffusion throughout these materials.

HANS ESSER (Institut für Eisenhüttenkunde der Technischen Hochschule Aachen).—£100, in aid of a research on the true structure of metals.

ERIC W. FELL (Manchester University).—£50, in aid of a research on the breakdown of elastic behaviour in steel and its avoidance.

ROSEVELT GRIFFITHS (University College of Swansea).—£50, to study some fundamental aspects of the scaling of iron and steel.

LEON GUILLET, JUN., and PAUL G. BASTIEN (Ecole Centrale des Arts et Manufactures de Paris).—£100, in aid of a research on the influence of some special elements on certain properties of cast irons.

BO O. W. L. LJUNGGREN (Metallografiska Institutet, Stockholm).—£100, for a research on the microsclerometric investigation of grain boundaries.

OTTO REIF (Eisenhüttenmannisches Institut der Technischen Hochschule, Berlin).—£100, in aid of a research on the scaling of iron and metals.

WILLIAM S. WALKER (College of Technology, Manchester).—£50, in aid of a research on quantitative thermal analysis.

JAMES WHITE (Royal Technical College, Glasgow).—£100, in aid of a research on equilibria at high temperatures in systems containing ferric oxide.

C. BOOTH (The University, Sheffield).—£50, in aid of investigations on basic refractories with particular reference to their use in linings of induction furnaces. (Second grant.)

*Andrew Carnegie Silver Medal.*—The Andrew Carnegie Silver Medal for the year 1936 was awarded to Privatdozent Dr.-Ing. Dr. mont. H. Esser for his Paper on "The Allotropy of Iron."

*Williams Prize for* 1936.—For the third year in succession, no award of the Williams Prize was made. The Council deplore the fact that, although the Papers presented to the Institute during the year were of high merit, as regards both interest and importance, none of them qualified for the award of the Williams Prize. This prize was presented by the late Mr. Illtyd Williams when he resigned his position as honorary treasurer of the Institute, with the object of encouraging the writing of Papers by younger members.

The Retiring President moved the adoption of the report, which was seconded by Sir Frederick Mills and carried.

The Retiring President then announced that the ballot papers had been scrutinised, and that all the proposals for election had been carried.

### Induction of President

The Retiring President said it was a particular pleasure to him to induct Mr. Alfred Hutchinson, M.A., the newly-elected President, into the chair. Mr. Hutchinson had been a member of the Institute for 43 years. He was well known to all the members of the Council, who received valuable opinions from him on any point that arose. Without more ado he would ask Mr. Hutchinson to take the chair, and in doing so he was sure he could express on the members' behalf, as well as on his own, their wishes to Mr. Hutchinson for a most successful and happy year of office.

The President (Mr. Alfred Hutchinson) thanked Sir Harold Carpenter for the very kind words he had uttered in inducting him into the chair. He also thanked the Council for the great honour they had conferred upon him by electing him to the highest position which the Institute could offer to any of its members, namely, the presidency of the Institute. He hoped the Institute would have a successful year while he occupied the chair.

Sir Robert Hadfield, proposing a vote of thanks to the retiring President, said that, as the senior Past-President, he had the honour to propose the warmest possible vote of thanks to Sir Harold Carpenter. Sir Harold had, indeed, been a model President. He had represented in a very peculiar way not merely the scientific side of metallurgy, but he had been in contact a great deal with the practical side, too. The members had had, indeed, a very remarkable President in the person of Sir Harold Carpenter.

The motion was carried by prolonged applause.

Sir Harold Carpenter, in acknowledging the vote, said he regarded it as a very special honour that the vote of thanks had been moved by Sir Robert Hadfield, and he desired to thank Sir Robert for what he had said. He had enjoyed his two years of office very much indeed. He had been sustained by the active efforts of the Council, by the splendid work of the staff, and by the goodwill and friendship of the members.

The President said his first pleasurable duty on taking office was to offer a very sincere welcome to the members and visitors from overseas. There were representatives from Belgium, from France, from Germany, from Luxemburg, from Spain, from the United States of America and from Poland—which he thought emphasised the international character of the Institute. He desired particularly to extend a hearty welcome to their friends from Germany. The members had the pleasantest recollection of the very successful meeting which had been held in Düsseldorf last September. The hospitality and generous entertainment of their Düsseldorf friends had been beyond all praise. The presence of Dr. Goerens was considered a particular compliment, as he had paid a short visit to England only a week ago for the International Congress for Testing Materials, and the members would very much like to congratulate him on his election then as President of that body.

Continuing, the President said he had the important announcement to make that an invitation had been received from the American Iron and Steel Institute and the American Institute of Mining and Metallurgical Engineers to hold the autumn meeting of 1938 in America, and that the Council on the members' behalf had accepted that invitation.

Dr. Goerens said he was honoured to bring to the members the greetings of the Verein deutscher Eisenhüttenleute. Their President, Dr. Springorum, regretted deeply the fact that he was not able to be present owing to illness, but the present news was that before long he would be completely restored to health. Dr. Springorum had asked him to express his profound thanks for the invitation to be present and for the hospitality and reception accorded to his colleagues.

The President said he had great pleasure in announcing that Dr. Fritz Springorum and Dr. Ernst Poensgen had been nominated by the Council to be honorary Vice-Presidents, and Dr. Otto Petersen as Honorary Member.

Dr. Ernst Poensgen thanked the President for the very kind words he had spoken in announcing his nomination as honorary Vice-President, and he thanked the members for the very kind applause with which they had acclaimed the high distinction which had just been bestowed upon him. He felt exceedingly honoured by being made a member of the Iron and Steel Institute, and he felt delighted at being appointed an honorary Vice-President.

Dr. Otto Petersen said he rejoiced at the honour bestowed upon him of being elected an honorary member of the Institute. The honour the Institute had done his President, Dr. Springorum, in making him an honorary Vice-President was accepted by that gentleman with deep thanks and he hoped to be able to put his thanks personally before the members.

### Presentation of Bessemer Gold Medal

The President announced that a Bessemer Gold Medal had been awarded to Colonel N. T. Belaiew, C.B., a distinguished pupil of the late Prof. Tschernoff, of the Military Academy, Petrograd. During the last five-and-twenty years Colonel Belaiew had published a series of researches which bore on the crystallisation of metals and in particular of steel. The presentation was made to Colonel Belaiew amidst prolonged applause.

Colonel N. T. Belaiew suitably acknowledged the presentation, and thanked the Council for the very kind way in which his name had been associated with that of his teacher, Tschernoff.

The President said he then had pleasure in presenting a Bessemer Gold Medal to M. Aloyse Meyer, whose whole career had been devoted to the technical and industrial development of the iron and steel industry. He had started as engineer in 1904 at the Hauts Fourneaux et Aciéries de Dudelange, one of the first works in Europe and the first in the Lorraine Luxemburg district to adopt the Thomas Gilchrist process which revolutionised the manufacture of steel on the Continent. The presentation was made amid prolonged applause.

M. Aloyse Meyer, in acknowledging the presentation, said it would be difficult for him to give adequate expression to his feelings of proud gratitude in receiving the Bessemer Medal. He deeply felt the honour which the Institute conferred on him in granting him the highest award in its gift, an award so greatly appreciated all over the world.

## PRESIDENTIAL ADDRESS

Mr. Alfred Hutchinson, in the course of his Presidential Address, said that the first visit of the Iron and Steel Institute to the Middlesbrough district was in 1869, and the visitors must have seen a fully-developed wrought-iron and pig-iron industry in active operation. Following the discovery of ironstone in the Eston Hills, 17 mines had been opened up and 167 blast furnaces erected. The pig-iron so produced formed the raw material for the foundry trade in the district and in Scotland, and for the wrought-iron trade. The point of technical importance was that the liquid pig-iron produced was allowed to cool on the pig beds, so losing its initial heat, and was sent as cold pig-iron to foundries or forges, in which it had to be remelted to produce finished products, and the finishing operations of a large proportion of the pig-iron output were conducted in other districts.

The members of the Institute who would visit Middlesbrough in the autumn of this year, continued the speaker, will find a very different state of affairs. The wrought-iron trade has completely disappeared, being replaced by steelworks, in many of which the molten pig iron is converted into steel without the loss of its original heat and rolled into finished steel products on the spot, and in some cases there are attached to such steelworks finishing departments in which the essential parts of structural steel buildings are manufactured. Even the basic-Bessemer process has entirely disappeared. The plant in which basic-Bessemer steel was first produced at Cleveland Works has recently been demolished to make room for a stockyard for ingots produced by the basic open-hearth process in a thoroughly up-to-date basic open-hearth plant. Referring to the notable inventions and discoveries which led to the complete disappearance of the making of wrought iron in the district, the introduction of the manufacture of steel by the basic-Bessemer process and its ultimate abandonment in the North-East Coast district, the speaker said that discoveries and inventions in all branches of metallurgy and engineering have effected this great change.

After referring to specific examples of the progress made in the Cleveland area in the direction of blast-furnace operation, steelmaking and coke-oven practice, the President said that side by side with this general improvement, other industries in the district using steel and iron have made great progress. The foundries have expanded, the most modern and up-to-date plant being Messrs. Cochrane's new pipe foundry, where Mr. E. J. Fox had erected upon the site of the old blast furnaces, now dismantled, a thoroughly up-to-date plant for making spun pipes, and thus achieved the same success as he formerly did at his Stanton Works in the Midlands.

Finally, may I remind members of the Institute that it exists for the promotion of research. The great improvements which I have outlined are the direct result of research, to which many great minds in the past devoted their whole lives. Under the auspices of this Institute and the Research Department of the British Iron and Steel Federation, active research has been stimulated in every department of the trade. In such research the Cleveland district has played no unworthy part. It was Sir Isaac Lowthian Bell, who, at Clarence, carried out the great experiments on the principles of blast-furnace practice which remained the classic on the subject for over 50 years. Indeed, it is remarkable how little new work was done on this important matter until comparatively recently, and when new work was started it was by Prof. Bone, a native of Stockton, who had already made for himself a world-wide reputation by his researches on the explosion of gases, which he had carried out over a long period of years at the Imperial College of Science and Technology. Such researches require for their prosecution the highly-trained mind not only of the man who directs the research but of the large band of highly-qualified research students who work under him. Prof. Bone, after publishing most important Papers on the laboratory investigations and the reactions which take place in the blast furnace, will shortly publish his accounts of field works experiments in the Lincolnshire area, and these are being followed up by experiments to be conducted on the new blast furnace recently blown in at Skinningrove.

It is not only academic research for which this Institute stands. Its desire is to encourage in every possible way inquiry into all possible means of improving the processes of steel and iron making, and to this end it should prove helpful to those members who are the practical managers of works in which steel and various other products are produced. In a sense every workman who makes the smallest suggestion towards the improvement of the working operations of his plant is a worthy successor to the greater minds who invented the fundamental process on which the industry rests.

The speaker concluded with a few personal references notably to the memory of his father who, without previous experience in pig-iron manufacture, on taking charge of a small plant at Skinningrove turned his attention at once to improving its method of operation in every possible way. He improved the distribution of the materials in the furnace by altering the diameter of the bell, thereby reducing his coke consumption by 2 cwts. per ton of pig-iron and getting increased makes; he adopted Cowper stoves in place of pipe stoves—a further reduction of 2 cwts.—and, to get out of the difficulties of excessive railway carriage, invented from blast-

furnace slag the hydraulic cement and with it built a jetty which facilitated transport by sea.

When, later on, the ironstone accessible to the works without railway dues became contaminated with shale, which when smelted in the blast furnace increased the coke and lime consumption and the consequent cost of the pig-iron, he completed a mechanical process of cleaning the ironstone by the erection of belts at Skinningrove and later at Boulby. By this means he restored his costs to normal and proved that it is cheaper to clean ironstone mechanically than to smelt shale in the blast furnace.

He thus inspired all his staff with the desire for progress and economy, and later, when building steelworks, encouraged the adoption of electric rolling; during the war he supported the members of his staff—notably Mr. Ernest Bury, who invented his own methods for the manufacture of T.N.T. (trinitrotoluol), poison gas and potash from coke-oven and blast-furnace products, which were badly required in the time of national need.

Cleveland has produced through two generations men whose names were great in research and invention—Sir Isaac Lowthian Bell, Mr. Windsor Richards, Sir Arthur Dorman, Mr. Benjamin Talbot, Dr. J. E. Stead. All played a great part in laying the foundation of the future prosperity of the district, and it is for those members of the Institute who are left to carry on their work to see to it that in the future improvements and economies are effected in the industry which is so important to the nation, and, indeed, to the whole civilised world.

## THE ANNUAL DINNER

The Annual Dinner of the Iron and Steel Institute was held at Grosvenor House, Park Lane, London, W.1, on Thursday, April 29. Mr. Alfred Hutchinson, M.A. (President), occupied the chair, and over six hundred members and guests attended, the latter including the Rt. Hon. Ernest Brown, P.C., M.P. (Minister of Labour), the Rt. Hon. Lord Aberconway, C.B.E., Col. N. T. Belaiew, C.B., Prof. Carl Benedicks (Hon. Vice-President), Herr. A. von Bohlen and Halbach, the Rt. Hon. the Earl of Dudley, M.C. (President, British Cast Iron Research Association), Sir Andrew Duncan (Chairman, British Iron and Steel Federation), Prof. Dr. P. Goerens, the Rt. Hon. Viscount Greenwood, P.C., K.C., Sir William Larke, K.B.E. (Director, British Iron and Steel Federation), the Rt. Hon. Lord May, K.B.E., M. Aloyse Meyer, Dr. E. Poensgen, Sir Arthur Pugh, C.B.E., Marshal the Viscount Trenchard, G.C.B., G.C.V.O., and many others.

THE RT. HON. ERNEST BROWN, P.C., M.P. (Minister of Labour), proposing the toast of "The Iron and Steel Institute and The Iron and Steel Industries," said it was a very great pleasure to him to have the honour of proposing that toast. Several years ago, a toast of that kind would have caused a good deal of ironical comment and might have been regarded as a mockery; but it was his good fortune to propose the toast when it was a very welcome one, and appropriate to the present conditions of the industry. He, of course, viewed the industry from two points of view, first of all having regard to it as a great productive industry, and secondly, having regard to it from his particular watch-tower at the Ministry of Labour. That watch-tower was not the least interesting watch-tower in this country. The Ministry of Labour, of course, was a place where facts were presented for the most part in the form of statistics. People were sometimes inclined to doubt statistics, but no one need doubt those he was about to give. The steel industry showed a partial recovery and a tremendous drop in the last five years in the numbers of those unemployed. In 1924 there were 240,000 insured workers aged 16 to 64 in that particular group; in 1931 there were 189,000, in 1935 there were 178,000, and in 1936, 186,000. He had no doubt that by July, 1937, they would be again near the 200,000 figure. Those were eloquent statistics and they were accurate statistics.

Continuing, the speaker said perhaps his hearers would bear with him while he gave the still more remarkable figures of the decline in unemployed workers in the industry. In March, 1932, there were 87,000 unemployed; in March, 1936, that figure had dropped to 32,000, and in March, 1937, to 22,000, a reduction of no less than 75 per cent. in five years. The production of pig-iron had expanded from 3,772,600 tons in 1931 to 7,685,700 tons last year, and the production of steel ingots and castings from 5,202,600 tons in 1931 to 11,698,200 tons last year. That was a very remarkable recovery, and the figures for the first three months show that this year was likely to be in advance of last year.

### President's Reply

The PRESIDENT (Mr. Alfred Hutchinson, M.A.) said it was with very great pleasure that he rose to respond to the toast proposing success to the Iron and Steel Institute. He thought he saw signs of the fulfilment of the good wishes of the Minister of Labour. In the first place, he (the speaker) was glad to be able to report an increasing membership, which had now reached 2,243, the highest figure yet attained. The previous record was 2,228 in 1921. But it was not only figures that counted. He was confident of the continued loyalty to the Institute not only of the individual members, but also of the many large combines and firms which controlled their great industry.

The Iron and Steel Institute came into being at a very important period of the history of the development of the technical side of the industry; its formation in 1869 definitely gave a national and international character to the co-ordination of discoveries and inventions. The Institute afforded a means by which all who were interested in research could meet regularly and read and discuss Papers, and men to whom research was the very breath of life were assured of a patient hearing and of a warm welcome for discoveries which might ultimately prove to be of benefit to the whole trade. The Institute was founded by nine prominent ironmasters of that day with the very definite object of affording a means of communication between members of the steel trade upon matters bearing upon their respective manufactures. Considering all that had happened during the succeeding sixty-eight years, and the large company gathered in that room under its auspices, he thought one must admit that its founders were men of great foresight.

Apart from the subject of pure research, there were many other matters which were dealt with by the Institute. Of very great importance were the Papers which were published dealing with the practical applications of discoveries not only in metallurgy but also in many kindred branches of science. Personally, it was his earnest wish that there shall be presented to the Institute an ever-increasing number of Papers on the practical side, and he appealed to the younger members of the Institute to come to its assistance in this direction. To him (the speaker) it was a fascinating thing to visit any modern steelworks and to see the various applications of technical science which in any particular plant had led to a reduction in fuel and other costs and to the adoption of labour-saving devices.

The RT. HON. VISCOUNT GREENWOOD OF HOLBOURNE, P.C., K.C., who responded on behalf of the Industry, said that as chairman of Dorman, Long, he spoke with the greatest pleasure and with some pride on behalf of the industry in thanking his Right Hon. friend, Mr. Ernest Brown, for his remarks with reference to their great industry.

Continuing, the speaker said it was the greatest popular delusion that the steel trade was enjoying any more prosperity than was its due. People forgot that for many years, in the case of the company of which he had the honour to be chairman for fourteen years—the ordinary shareholders never had a dividend. Tens of millions of capital had been wiped out and all sorts of burdens had been borne without profit for years past. Now that they were coming into their own, thanks to the policy of the Government plus the capacity and earnestness of all ranks in the industry, he thought it was a great mistake to impute to them a desire to be unfair to the public or to do other than try to preserve the fabric of their industry. Every one was looking forward to the time when it would not be so easy to sell steel as it was to-day. On that point, it ought also to be understood that the steel trade had not the power to fix its own prices. They were an industry which was handed over to an impartial tribunal, for which they had the greatest respect; but if the tribunal fixed the prices the trade did not, and he thought that that ought to be understood.

There was one other thing that he (the speaker) wanted to say. He was one of those who believed in the present Chancellor of the Exchequer; he thought it was a mistake to imagine for a moment that his recent speech would mean a burden on and cause the trouble to the steel industry that some people feared. The statement which they must keep in mind was that the Chancellor wished to levy on the profits of nearly the whole community some £20,000,000 or £25,000,000 next year, and the method of levying must and could only be such as would produce that maximum amount. That being clearly understood, he (the speaker) thought that the profits of the country could stand the burden.

MR. JOHN CRAIG, C.B.E., proposed the toast of "The Guests," and DR. ING.E.H. ERNST POENSGEN responded for the overseas members and guests, and SIR ARTHUR PUGH, C.B.E., on behalf of the English guests.

MR. JAMES HENDERSON (hon. treasurer) proposed "The President," who briefly responded.

Amongst those present well known in the foundry industry were:—W. R. Barclay (President of the Institute of Metals), Major T. G. Bird, P. B. Brown, A. Burgess, D. F. Campbell, G. Clayton, H. E. Cookson, Verdon O. Cutts, J. Deschamps, W. J. Dawson, V. Delport, A. B. Everest, C. K. Everitt, V. C. Faulkner (Past-President of the Institute of British Foundrymen), Ambrose Firth, E. J. Fox, G. E. France, J. W. Gardom, J. T. Goodwin (Past-President of the Institute of British Foundrymen), F. J. Hemming, Barrington Hooper, C.B.E. (managing director, FOUNDRY TRADE JOURNAL), J. E. Hurst (Past-President of the Institute of British Foundrymen), C. H. Kain, H. W. Lockwood, G. T. Lunt, T. Makemson (secretary of the Institute of British Foundrymen), S. Osborn, J. G. Pearce (director of the British Cast Iron Research Association), A. G. Robiette, F. S. Russell, J. A. Smeeton, Dr. T. Swinden, H. B. Toy, S. V. Toy, A. C. Turner, T. Henry Turner, M. Van Marle, H. Winterton (President of the Institute of British Foundrymen).

### General Refractories

At the Manchester Coronation Exhibition, which is being held from April 28 to May 14, General Refractories, Limited, Sheffield, are showing a special display of basic refractories which include the new Saxpyre brick. This brick combines better spalling resistance with high refractability under load. Its improved properties allow a Saxpyre brick to be used in exposed positions with a greater margin of safety, and with greater durability for basic open-hearth furnaces, electric steel furnaces, soaking pits, re-heating furnaces and copper smelting furnaces. On view also is a display of insulating bricks of every type, manufactured at Colchester and Ambergate. It is claimed that these bricks save 20 per cent. of fuel, and 80 per cent. of waste heat. Other exhibits include Dykehead firebricks and plastic refractories called "Durax," possessing improved properties.

# Oil Cores and Their Testing*

By H. NIPPER (The Foundry Institute of the Aachen Technical High School)

Numerous articles dealing with various portions of the field covered by the present Paper have appeared in foundry literature of recent years. It would appear appropriate to review and comprehensively summarise the requirements which an oil core has to satisfy, as well as the properties conferred upon it by its structural elements and the treatment during its preparation. Such a review is certainly necessary, in view of the many oil core binders now on the market.

In the first place, therefore, this Paper will present a review in its broad outlines, and in addition will discuss methods of testing and investigation, as well as the practical works' control of oil cores, together with some recent experimental results.

The knowledge that oil can be used as binder in the production of foundry cores is very old. In an article dealing with moulding and foundry practice, Piwowarsky[1] mentions that even in the sixth century before Christ, during the classical period of Greek bronze casting, binders of an oily nature were used for the production of cores. It is, however, only with the enormous increase witnessed in the last few years in the production of complicated, high-grade and often extremely thin-walled castings that the oil sand core has been employed in considerable quantities by various branches of the industry. In foundries which cast motor car engine cylinders, small oil cores are used for strainer and runner purposes, while others after being carefully tested for constant dimensions are assembled to form complicated core assemblies. Even oil cores of considerable size and weight are used, and Craven Bros. (Manchester), Limited, report the successful application of an oil core weighing 5 tons and measuring 13 ft. in length.[2]

### Essential Requirements

In many respects, oil cores have excellent properties, depending upon the individual structural components of the core and its method of preparation. Six different ranges of stress are distinguished with regard to the behaviour of an oil core sand or an oil core during preparation and use. A distinction is made between the properties and behaviour of:—

(1) The oil sand mix ready for use, also during forming.

(2) The core in the green or raw state before drying and baking.

(3) The core during drying and baking.

(4) The core in the dried and baked condition.

(5) The core while being heated by the molten metal and its gradual change during the solidification and further cooling of the casting.

(6) The core or core material during cleaning (and possibly during preparation).

The oil-sand mix when ready for use should be homogeneous and possess a high degree of plasticity and mould-filling capacity. Consequently, when introduced into the core box, it should rapidly attain the maximum density and hence strength in the green and unbaked condition, independently, to a large extent, of the nature of the ramming. It should be sufficiently durable and cheap.

In the green, undried and unbaked condition, the oil core should possess high rigidity and should consequently preserve its dimensions and resist vibration during transport. Uniformity of structure (porosity) and a smooth and clean surface are essential.

During drying and baking, the core should harden uniformly, should only require short drying periods and should be unaffected by variations in the drying time and by sudden heating or cooling. It should require only a low drying temperature and should not be affected if that temperature is exceeded or is not attained. During drying, the core should only require a minimum volume of air and should evolve little moisture or gas. It should possess satisfactory rigidity. Any change in shape resulting from drying and the oxidation of the oil binder should only be slight.

In the dried and baked condition, the core should possess high compression, shearing and bending strengths. It should exhibit a high degree of hardness, sharpness of the edges and resistance to abrasion. It should be very permeable to gases, uniform in structure, and should have only a slight tendency to absorb moisture, while being extremely durable.

When heated in the mould by the molten metal, the core should possess constancy of dimensions to a high degree, and even at high temperatures it should possess good compression, shearing and bending strengths, hardness, sharpness of the edges and resistance to abrasion. While being highly refractory even at elevated temperatures, the core should be permeable and homogeneous in structure. Its thermal conductivity should correspond to the desired rate of cooling of the casting. When in contact with the hot metal, the core should evolve the least possible amount of gas and any gas evolved should be safe in every respect, that is, should not be poisonous or inflammable, and should not inconvenience the workmen.

During fettling, the core residues should consist of a loose, easily removed sand mixture. As far as possible, the whole of the binder should have been burnt out of the core. It should be possible to use the core sand again and the casting should have a clean, smooth surface.

The components upon which the structure of an oil sand and oil core primarily depend are the core sand and the oil binder.

### Characteristics of Core Sand

Core sands may be distinguished by the size of the grain; shape of the grain; nature of the surface of the grain; mineralogical composition of the various grades of the grain; clay content (the mineralogical composition, quantity and distribution of the clay), and moisture content.

The size of the grains of a core sand should be as uniform as possible and depends upon the desired smoothness of the surface of the casting. The principal fractions of a good core sand amount to about 70 per cent. or more for a uniform size of grain of 0.1 to 0.4 mm. in diameter, according to the nature of the casting. The coarser the sand, the easier it is to produce a good mix. A core made of coarse sand is more permeable and requires less oil for binding in view of the smaller number of points of contact between the quartz grains. Finer sand with numerous points of contact, if dried carefully and correctly and mixed with a sufficient quantity of oil, will give stronger and harder cores. Coarse sand can be dried and baked much more rapidly and uniformly and less gas is evolved during casting.

The grains of sand should be as spherical as possible, permeability being then a maximum, while the maximum quantity of oil is required. The sand mix can be easily prepared and dried and the optimum mould-filling capacity will be obtained. The ramming energy which is necessary for securing optimum compression is substantially less for round grains than for angular, sharp-edged grains. The surface of the grains should be as uneven as possible and rough (etched dull) because then the oil films adhere with particular firmness.

The mineralogical composition of the various grades of grain has a considerable influence on the refractoriness. Pure quartz grains should be present in the core sand. The influence of the nature of the mineral on the adhesion of the oil films is slight.

### Influence of Clay Content

Clay in the sand increases the difficulty of uniformly mixing the sand with the oil binder; increases the amount of oil which has to be added, and reduces permeability. The mixture of oil and clay blocks the pores. The rigidity of the core in the green condition increases with the amount of water added simultaneously. In the dried condition, it diminishes throughout. The durability of the cores decreases, the tendency to absorb moisture increases, and the unfavourable effect of such absorption is also increased.

Additions of 2 to 4 per cent. of water, particularly in the case of low oil contents, result in a good and uniform mixing and, particularly in the case of high clay contents, have a favourable effect on the strength of the cores in the green condition, and also result in a slight increase in the strength in the dried condition. High moisture contents diminish the strength of the cores in the baked condition.

Pure washed quartz sand (dune or river sand) having uniform round grains with rough surfaces produce the best oil cores. Additions of water and clay are justified according to the nature of the oil binder employed, and mainly effect an increase in strength of the core in the baked condition. Testing of the sand should, of course, be carried out in accordance with any standard methods which may exist.

### The Oil Binder

The second component which determines the structure of an oil sand and core is the oil binder. The broad groups to be distinguished are vegetable, animal and mineral oils. Animal oils generally give rise to a very unpleasant odour in use. As the result of skilful preparation, such as fractional distillation, and in view of their good binding properties, they are being used to-day on a more extensive scale for core making.

Examination of certain mineral oils has also shown that very good binding powers can be attained with these oils, particularly with additions of resin and pitch. Vegetable oils, however, are particularly suitable for the production of oil cores. Linseed oil is the most popular binder. About 90 per cent. of the oil consists of liquid unsaturated fatty acid glycerides which, upon oxidation, produce a dry, firm bond between the quartz grains.

Core-binding oils employed in practice generally contain considerable amounts of additional materials, differing widely in character. Resin oil, pitch oil, tar oil or tar oil and sulphite liquor with slight additions of linseed oil are met with most frequently. The direct testing of oils in the laboratory provides little information regarding their value as core binders, and only pure oils can be tested satisfactorily in this manner. The specifications given by Crosby[3] also relate to pure oils.

| | | |
|---|---|---|
| Iodine number .. .. | min. | 155 |
| Saponification number | min. | 198 |
| Acid number .. .. .. | | 34 to 44 |
| Fire point .. .. .. | | 82 to 99 deg. C. |
| Flash point .. .. .. | | 74 to 90 deg. C. |
| Specific gravity .. .. | max. | 0.934 |

Fresh odour and pale yellow, clear colour.

The saponification and iodine numbers indicate the content of unsaturated fatty acids. Their determination is therefore of particular

* Paper presented to the last International Foundry Congress in Düsseldorf.

1 "Technikgeschichte," Vol. 22, 1933, V.D.I.-Verlag G.m.b.H.

2 FOUNDRY TRADE JOURNAL, August 25, 1932, p. 110.

3 Transactions of the American Foundrymen's Association, Vol. 35 (1927), p. 148.

value in the case of pure oils. With regard to oil mixtures, one is dependent upon the direct laboratory examination of the bonding power of an oil or upon the investigation of test cores.

### Oil Testing

In the Aachen Foundry Institute, the following method of testing the bonding power of an oil has been found to be particularly reliable. Clean rings of metal or quartz made to fit one upon the other (Fig. 1) are slightly moistened with oil, and are baked for a certain time in an oven at the test temperature with constant circulation of air. The rings are then clamped

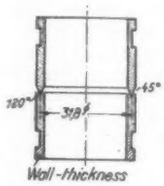


FIG. 1.—METAL AND QUARTZ RINGS FOR TESTING THE BOND STRENGTH OF CORE OIL.

by means of their grooves in a device specially designed for the purpose and the films of binding oil are ruptured. The total length of the rupture is about 100 mm. and the width of the oil film is exceedingly small, being about $\frac{1}{3}$ or 1 mm., so that altogether a surface of adhesion of about $\frac{1}{2}$ to 1 sq. cm. is provided. Adhesive strengths of 20 kgrms. or more are obtained, depending on the nature of the oil, the drying temperature and the drying period. Pure quartz rings give higher values than smooth rings of brass or aluminium and about the same values as etched and roughened metal rings. The test is very delicate and is particularly suitable for ascertaining the best baking conditions for different kinds of oil.

### Mixtures and their Effect

In addition to the structural components of a core sand and core—quartz sand with its additions, and oil with its additions—the method of making the core also has a considerable effect on its properties and behaviour. In the first place, the mixing ratio of sand and oil, including any additional materials such as clay or foundry sand and water, is of the greatest importance.

Microscopic examination of thin sections of oil cores having different oil contents clearly shows how an excessive proportion of oil causes the pores to be stopped up. Assuming a uniform grain diameter of 0.2 mm., the thickness of the oil film is found by calculation to be from 0.0025

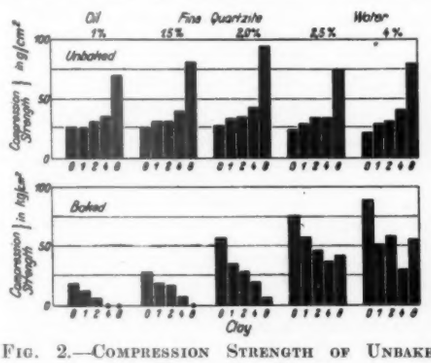


FIG. 2.—COMPRESSION STRENGTH OF UNBAKED AND BAKED OIL CORES.

to 0.005 mm., *i.e.*, about $\frac{1}{100}$ to $\frac{1}{50}$ of the grain diameter, which is in close agreement with the microscopic examination of thin sections. The thickness of the oil film, the nature of the contact between the grains (round or angular grains), the grain size and clay content exert an influence on the thermal conductivity. Oil cores made in the Aachen Foundry Institute from fine, uniform sand, such as is sometimes employed for sand-blast purposes, when used in moulds for discharge spirals, gave a considerable increase in the rate of removal of heat from the molten metal, although it was not possible to secure an actual chill effect.

With a fine grain and high oil content, permeability decreases considerably, and this generally applies to the strength also, since it is then not a very easy matter to secure adequate drying of the oil films in the interior of the cores. There is also a danger of excessive evolution of gas from the cores when in contact with the molten metal. This factor will be discussed later.

Mixes having a high content of moulding sand, *i.e.*, a high clay content, and correspondingly high oil contents, when examined microscopically in thin section, show that the pores of the cores are stopped up to a still further degree, and the strength in the dried state is considerably less. Satisfactory oxidation with the formation of firm and strong binding films in the interior of the core can only be attained with difficulty and is a tedious operation.

Fig. 2 shows some results of the author's earlier work,[4] and the effect of an increasing clay content on the strength of green and baked oil-sand cores is clearly to be seen. The measure adopted for indicating the strength in the green state was the load which caused rupture of the outer skin of the core or which produced a definite reduction in height of the core. In the green state, the strength increases with the clay content, while the addition of clay causes the strength to fall off considerably in the baked condition.

### Mixing Properties of Oil

The core sand should be mixed long enough to coat each individual grain of quartz uniformly with a fine film of oil. With a good oil, this film shrinks on drying at the points of contact between the individual grains to form a somewhat thicker film. The remainder of the surface of the core is merely coated with a very thin lustrous layer. The thinner the oil, the sooner will perfect mixing be accomplished. During mixing, the grain of the sand should not be destroyed by excessive grinding in the edge runner mill. A slight addition of water may promote the uniform dispersion of the oil binder. It is best to use the oil sand immediately after mixing so as to avoid troublesome oxidation.

The method of ramming the sand during the making of the cores has a considerable bearing on their properties, particularly the density, permeability and strength. Sharp-edged, splintery grains are much more difficult to ram than uniformly round grains, but after adequate ramming give higher strengths with lower permeability.

### Drying and Baking

When drying and baking the core, the maximum strength is attained by placing the core in the cold oven and then slowly raising the temperature to the baking point and completing the baking. It is then possible for the drying operation to be completed to a considerable extent before any substantial oxidation commences. As a rule, it is not possible to proceed in this way in practice, and the cores have to be placed in the ovens when the latter are already at baking temperature. In the most favourable case, the cores pass through a small zone of initial heating, but there is always a danger that the firm oxidised films which form more rapidly on the outside of the core will be loosened again by the gases and vapours escaping from the interior of the core. It is particularly the outer edges of the core, which ought to be very firm and sharp and resistance to abrasive stress, that are loosened, and the consequences are often the removal of sand by abrasion and defective surfaces of the castings, especially in the case of light metal and sand cores for chill castings.

Since the binding films of oil are to be dried and oxidised, hot air must circulate round and through the cores. The period of drying for an oven temperature of about 220 deg. C. in practice is normally 1 to $1\frac{1}{2}$ hrs. for small cores. Even if the temperature is too high, it is still possible to make serviceable cores by shortening the baking periods and, conversely, in the case of abnormally low temperatures (150 deg. C.), production is successful with long baking periods. Good oils are but little affected by variations in the baking temperature and time.

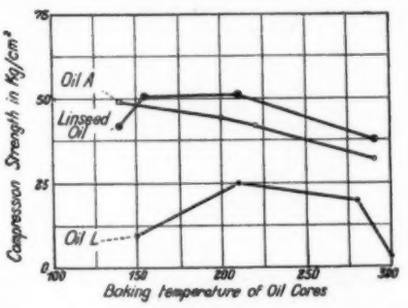


FIG. 3.—COMPRESSION STRENGTH OF OIL SAND CORES.

### Thermal Tests

Table I shows the granular composition of two samples of core sand with which a number of investigations were made. The compression strength, shearing strength and permeability were determined for different drying temperatures. Test cylinders 50 mm. dia. and 50 mm. in height were dried in an electrically-heated, automatically-regulated baking oven with a regulated gentle supply of preheated air for 2 hrs. at 150 deg. C., for $1\frac{1}{2}$ hrs. at 220 deg. C. and for 1 hr. at 300 deg. C. (Before testing, it is, of course, necessary to see that the faces of the treated cores are definitely parallel. Any discrepancy can be removed by grinding between parallel wheels).

TABLE I.—*Granular Composition of the Core Sands Employed.*

| Grains .. .. | — 0.3 mm. | 0.2 to 0.3 mm. | 0.1 to 0.2 mm. | 0.06 to 0.1 mm. | < 0.06 mm. | clay |
|---|---|---|---|---|---|---|
| Sand A (per cent.) | 0.3 | 80.0 | 16.8 | 2.0 | 0.4 | — |
| Sand L (per cent.) | 0.4 | 83.5 | 15.0 | 0.5 | 0.2 | — |

All the graphs shown in this Paper are primarily intended to indicate the fundamental behaviour of the oil cores according to the initial components, the method of preparation and the applied stress. The results of further work on the absolute values of numerous oil sand cores tested under various conditions will be reported on a subsequent occasion.

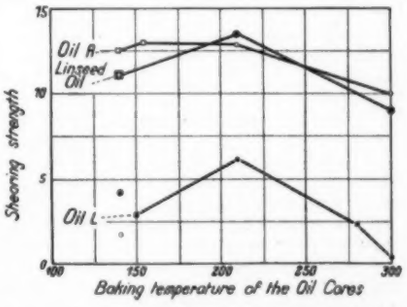


FIG. 4.—SHEARING STRENGTH OF OIL SAND CORES.

Fig. 3 shows the compression strengths of various oil cores treated in this way. A weak oil is very sensitive to temperature and, despite a baking period of 2 hrs., fails to provide a serviceable core at 150 deg. C. On the other hand,

(*Continued on page* 370.)

4 "Association Technique de Fonderie," No. 8 (1934), p. 373.

# Testing of Refractory Materials*

By S. M. PHELPS

There has been considerable activity in America in recent years in the development of test methods, definitions, specifications, and industrial surveys pertaining to refractory materials. The trend of this work has been along more practical lines than was the case in former years, and this is shown particularly in the development of some of the more recent test methods.

Committee C-8 of the American Society for Testing Materials is the most active group dealing with these matters in the refractories industry. For several years the Society has published a manual which includes information of value to both the consumer and the producer of refractory materials. The following comments indicate the nature of the different activities of Committee C-8.

### Tests

*Pyrometric Cone Equivalent.*—The relative refractoriness of both raw and fabricated refractory materials is determined by means of pyrometric cones. This property is designated as the pyrometric-cone equivalent of the material. The material to be tested is ground, formed into cones, and placed beside standardised cones so that during heat-treatment a comparison can be made of the refractoriness of the unknown as against the standard cones.

The problems on which work has been conducted in recent years in connection with this test are:—Size and shape of the cones, the rate of heating, and the type of furnace in which the test is conducted. Because of differences in gas atmosphere, velocity of the heated gases, and points in the design of the three types of furnaces, it appears that it will be necessary to standardise on one furnace of a particular design operated in a specific manner. The three types of furnace in common use are electrical carbon resistance with a refractory lining, natural gas and air-fired, and oxy-acetylene.

*Load Test.*—The testing of refractories under static load during heat-treatment has been in use for many years. Its use in recent years has been somewhat curtailed because it is seldom that conditions in industrial furnaces are simulated in the test. It does offer a means, however, of evaluating the refractoriness of the product, and this is useful to the manufacturer. A.S.T.M. procedures include the testing of a 9-in. full-sized fireclay brick on end under a pressure of 25 lbs. per sq. in. (1.7 kgs. per sq. cm.) at temperatures of 1,100, 1,300 1,350 and 1,450 deg. C. The latter test has recently been introduced for a super-grade of fireclay brick known as super-duty fireclay refractories. The test for silica brick calls for a temperature of 1,500 deg. C.

*Permanent Linear Change as a Result of Heat-Treatment.* — For the purpose of learning the constancy of volume of a finished product when heated to specific temperatures, there has recently been reintroduced a test which was once called a reheating test. Nine-inch bricks are measured before and after the test and are placed in a kiln and heated so as to reach a specified temperature in 3 hrs., and the heat is maintained for 5 hrs. There are three temperatures stipulated for three different grades of materials, that is, 1,200, 1,400 and 1,600 deg. C. The last temperature was recently adopted for the evaluation of super-duty fireclay brick.

*Spalling.*—The spalling of refractory materials has been determined in recent years by the panel-spalling test. The principle of this procedure is to make use of a panel measuring 18 in. sq. laid up with 14 standard-sized bricks, and the test surface of this panel is heated for 24 hrs. at either 1,600 or 1,650 deg. C., depending upon the grade of the fireclay refractory. During this preheating part of the test the backs of the panels are insulated with 4½ in. of specified insulating material. This preparatory treatment causes the surface of the brick to vitrify with an intensity and to a depth dependent upon the refractoriness and quality of the material. Later the test surfaces of the panels are subjected to thermal shock. This is accomplished by alternately heating the panel in front of a furnace operating at 1,400 deg. C., and then cooling by means of an air blast. After 12 such cycles of treatment the panels are dismantled and the loss in weight calculated as spalling loss.

The details of the design and operation of the equipment have been carefully standardised and the test has provided reliable information. This is accounted for by the practical nature of the test, which simulates average conditions in furnaces such as boiler furnaces, incinerators, and malleable-iron heating furnaces. Recent studies show the importance of maintaining within reasonable close limits the furnace pressure and the nature of its atmosphere during the preheating part of the test.

### Miscellaneous Test Procedures

Other test procedures which require no particular comment are:—

Determination of the cold-crushing strength, which is carried out on half-brick specimens. Transverse strength determined on full-sized brick with a 7-in. span between knife edges. Determination of the particle size of ground refractory materials which makes use of a dry- and wet-sieve analysis. The latter procedure is used particularly for testing fireclays for the purpose of breaking them down to their natural particle size by means of the accompanying water treatment.

The chemical analysis of various types of refractories carried out by procedures which have been standard for many years. The use of chemical analysis in connection with specifications has been restricted in recent years. Experience has shown that relatively small variations in the composition of many types of refractory materials are of little or no significance in judging the behaviour of these materials in industrial furnaces. This is particularly true of fireclay refractories, and for this reason, the chemical composition is not incorporated in specifications except as a means of broad classification such as for siliceous-fireclay materials as compared with the more usual types.

Through the co-operation of the U.S. Bureau of Standards there have been established standard samples of refractory materials which can be purchased at a nominal cost for use in checking the accuracy of chemical analyses. The exact composition of these materials has been determined and this information is supplied with each purchase. Materials available are 40, 60 and 70 per cent. alumina fireclay brick, flint and plastic clay, silica, chrome and magnesite finished refractories.

### Definitions

In order to define certain classes of refractory materials, there have been prepared definitions covering clay refractories, terms relating to refractories, and a definition in preparation pertaining to 50, 60 and 70 per cent. alumina diaspore brick. There are included in the definitions symbols relating to heat transmission.

### Specifications

There are at the present time specifications covering malleable iron furnaces with removable bungs, together with annealing ovens; another pertains to stationary boiler furnaces, and incorporates the requirements for several classes of furnaces in which there may be encountered varying degrees of spalling and slagging. A third pertains to marine boiler furnaces, and a fourth to refractories to be used in the construction of incinerators. There is also a specification pertaining to ground fireclay for use in laying up refractory clay brick.

### Insulating Firebrick

In the past few years considerable time has been devoted to the subject of insulating firebrick, and this work has been divided into two phases. One has had to do with the determination of the thermal conductivity of these materials and, incidentally, the determination of this property in the regular line of refractories. Co-operative work has been carried out in all the principal laboratories engaged in this subject, and it has been found that, because of different types of apparatus, a considerable variation is obtained in the data for conductivity. With the information which is available at present, it is not possible to ascertain the causes of the error or to be sure which datum is closest to being the true value. Because of this condition, aid has been sought and obtained in the U.S. Bureau of Standards for the study of the proper type and design of apparatus which should be used in obtaining thermal conductivity.

The second section of the work relates to the development of a satisfactory test method which can be used to evaluate the properties of this class of refractories. There are under study methods for determining shrinkage, cold strength and spalling resistance.

There is a distinct need for a satisfactory slagging test which would predict the probable behaviour of various types of refractories in certain furnace operations.

* Paper presented to the London Congress of the International Association for Testing Materials.

## Steel Scrap Supplies

The British Iron and Steel Corporation has purchased about 625,000 tons of steel scrap in the United States, for shipment before September. The deal was carried through by the Corporation and its agents on behalf of the ten member countries of the international scrap arrangement. These are Austria, Czecho-Slovakia, Germany, Great Britain, Hungary, Italy, Poland, Rumania, Sweden and Yugoslavia.

Representatives of the member countries of the International Scrap Convention met in Düsseldorf on April 26 for further consideration of the position, including a decision as to the distribution of the several hundred thousands of tons of scrap which have been bought. It was resolved not to fix any distribution quotas for individual countries, as sufficient material is available for covering the demand. Members are reported to have agreed to penalties for any overstepping of the prices fixed by the convention. The headquarters of the convention, which remains in force to the end of the year, are in London, and the agreement provides for the payment of a levy on the tonnage of scrap bought on common account for defraying the expenses of the management.

## Oil Cores and Their Testing

(*Continued from page* 369.)

with a baking period of 1 hr. at 300 deg. C., the bonding power is destroyed again. Increasing the baking period to 6 hrs. at 150 deg. C. considerably increased the strength in all cases.

Fig. 4 shows the results of shearing strength tests on oil cores of identical preparation. The diagram corresponds closely to that of the compression strength. Shearing strength tests are usually simpler to carry out on account of the low shearing force required, and they also give more uniform results. When making the test, the entire cross-section of the test piece (outer zone, inner zone and upper and lower end) is taken uniformly into account.

(*To be continued.*)

# South African Branch of the Institute of British Foundrymen

## INAUGURAL MEETING

The inaugural meeting of the South African Branch of the Institute of British Foundrymen was held on March 10 at Kelvin House, Johannesburg. The meeting was highly successful in every way, the following members of the Institute being present:—Mr. V. L. Dean, Mr. J. A. Durie, Mr. J. Tonge, Mr. T. Hirsch, Mr. A. L. Lewis, Mr. P. M. Boag, Mr. A. E. Lintott, Mr. J. Flucker, Mr. H. J. Bragg, Mr. W. C. Simpson, Mr. A. H. Mackay, Mr. A. W. Symmonds, Mr. H. Teubes, Mr. D. R. Godfrey, Mr. D. Paton, Mr. R. H. Smith, Mr. J. G. Finlay, Mr. A. H. Guy, Mr. H. Holdsworth, Mr. P. L. Ward, Mr. T. Nimmo Dewar, Mr. W. Dick, Mr. D. Macgillivray, Mr. T. Morrison, Mr. D. Lion Cachet, Mr. J. Scorgie, Mr. D. M. Davidson, Mr. L. Bernstein and Mr. A. Mildren. An apology for absence was received from Mr. J. Robertson.

The BRANCH-PRESIDENT, Mr. T. Nimmo Dewar, who was in the chair, welcomed the members present and pointed out that the size of the meeting augured well for the future of the Branch. He recalled that the proposal to form a Branch of the Institute in this country had arisen at an informal dinner which Mr. Guy gave to a few founders on his return from Europe. The proposal took shape in the right atmosphere and the goodwill which had then obtained was now given a wider application. Everyone realised the value of goodwill in the more serious aspects of life, but it frequently happened that it was dormant and only became apparent in times of stress. In these days of co-operation free association between employers must logically be carried further than hitherto.

The chairman further pointed out that most professions had institutes, but so far there had been no technical provision for the training of foundrymen in South Africa. Foundrymen played an important part in the economics of the country. There was nothing to replace the foundry adequately in the production of ferrous and non-ferrous products. The inauguration of the Branch meant that the industry in South Africa would be in a position to co-operate with the wider world, which must be to the advantage of the industry. South Africa was gathering engineers from all other countries because of the eminence of the gold mining industry, resulting in a brain-power achieved on the widest basis. The engineering industry was in a position to claim its share in the astounding results which had followed gold mining development.

### PRESIDENTIAL ADDRESS

The Chairman then delivered his presidential address, in the course of which he said:—Gentlemen: Looking back to the earliest days of the Witwatersrand and its mining industry, one finds that the ironfounder was very early upon the scene. Of the first three foundry equipments to be set up here, two at least were what one might call ready-made plants, transferred by ox-wagon from Kimberley. We can all appreciate the need of a foundry in those early days, when all the plant and equipment was carried by ox-wagon over a practically roadless country to the new fields. Moreover, even in those early days each mine would have its engineer and each engineer would see to it that he had a workshop and the essential tools to carry out repairs and adjustments on the spot. The "town" workshop was differentiated from the "mine" one, very early on, by the fact that the former had a foundry section and thus wider scope in the work it could undertake. It is evident that the "town" workshops were efficiently run by their proprietors and fully met the needs of the mines, or we would certainly have seen more foundries attached to mine workshops, especially when the days of amalgamations and larger and ever larger properties came along.

I understand that one mine foundry which is still operating on the West Rand was started up because in those days transport of material from Johannesburg was costly and Johannesburg foundries were prone to leave Far West inquiries to the Krugersdorp shop, which presently developed what were considered somewhat inflated ideas about the value of its work and the prices it could charge.

There are, even now, only two other mine foundries in operation, one belonging to the same group as the West Rand mine (Randfontein Estates) and the other to Crown Mines, a property organised on such a vast scale in every respect, including workshops, that it was logical to decide that a foundry for routine work was justifiable.

#### Early Efforts

One cannot help wondering what the inner history was of the Simmer and Jack foundry which was completely equipped just when the Anglo-Boer War broke out. The only castings which were ever turned out from it were some brass bushes required for military purposes. For mine use the foundry never produced a single article and, going East, that was, I believe, the end of mine foundries.

The introduction of the cyanide process gave local engineering shops and foundries a big fillip. One can imagine the number of cast iron specials that would be required to connect up the farms of wood stave and, later, of steel tanks which grew up on every producing property. While the completion of many of these closing pieces was a job that could scarcely be done by overseas competitors, the mine buyers of those days were evidently as keen as our present generation on the matter of price, and it is on record that they caused inquiries for certain more or less standardised specials to be sent to England for quotations. To the credit of the local foundries, when the delivered cost of the imported casting was worked out, it proved appreciably more than the prices charged by the man on the spot, which, I gather, were round about 4d. per lb. I have no doubt some are wondering if we shall ever see such prices again!

I believe that almost from the start of founding on the Rand, pig-iron was imported to sweeten up the scrap available. Gartsherrie was the favoured brand and Gartsherrie it remained for years until Indian and then South African pig displaced it; nevertheless this brand is still used in some coastal shops to this very day. I remember hearing of the adventures not long ago of one of our sales staff who was visiting these shops and talking of South African pig-iron. At one, started at least about the time of the discovery of the Rand, if not before, they were unfortunately well stocked; in fact, a "consignment" of No. 3 Gartsherrie was just being delivered. How much were they getting in? The reply, in reverent tones, was "Three tons." And how long would that last them? Well, three months, perhaps four—which brings into relief the quiet, even tenour of life at the coast as compared with the hectic life on the Rand.

#### From Jobbing to Manufacture

At another establishment in a rival coast town inquiry revealed that they had tried South African iron and that it was no good; nothing would persuade them to try it again. Matters could not be allowed to rest there, and further inquiries established the fact that the iron they had tried had been made in Pretoria some 25 years previously. It was probably the remnants which the critical founder here would not use! This brings into relief the great gulf separating inland from coastal industry in this vast land of ours.

During the years leading up to the world war, the engineering and foundry trades of the Southern Transvaal retained their primary character of jobbing establishments, equipped to handle work beyond the capacity of the mine shops. The war had not long been in progress, however, before it became necessary to regard local plant and equipment primarily from a manufacturing point of view. Thus, at a meeting of the Founders' Section of the Engineers' and Founders' Association, held in the committee room of the Chamber of Mines on April 23, 1917, Mr. Parsons, speaking on the subject of the production of pig-iron from local iron ore, is minuted as having remarked: "We have been forced to become manufacturers of plant whereas previously we have been called on to do maintenance work only."

May I say that from this date onwards the chief topics discussed by the founders seems to have been the Iron Moulders' Society and scrap. They celebrated the formation of the Founders' Section by a strike of iron moulders. At about the same time the price of pig-iron climbed to £12, £14 and £16 per ton, while some of the scrap-metal fraternity are recorded as holding up supplies for £7 10s. and more a ton while members were gravely agreeing not to pay more than £5!

As regards the Iron Moulders' Society, I note that they have not suffered a strike on their part for close on twenty years. I do not know whether to congratulate them or not, or whether it is their kindly, long-suffering nature or the extreme complaisance of the members of that Society which should be accorded the credit for this satisfactory state of affairs. I think we all kindle to the phrase "Give peace in our time."

It is interesting to contrast the position of the founders in 1917 with their position to-day, twenty years later. At that time scrap was almost unattainable and so was pig-iron. There was practically an embargo on the export of iron to any country from England, and you had to scour the world for supplies. Fortunate was he who could light upon a couple of hundred tons, and magnanimous, too, in that he would actually share his good fortune with his fellows. To-day we are faced with a growing shortage of scrap. On the other hand, the price of South African pig-iron is stabilised and this prevents the soaring of scrap prices. Moreover, there are now two blast furnaces at Pretoria, and when both are in regular operation in a few months' time, I see no reason why a grade of pig should not be available which will enable the founders to reverse the order of things hitherto, *viz.*, to use 70 per cent. pig to 30 per cent. scrap instead of *vice versa*. With such an iron at hand at a stable price you will truly feel that your lives lie in pleasant places!

#### Pioneers

To digress for a moment, I ought to emphasise that the history of the engineers and foundrymen of the Transvaal has never been written and that unfortunately most of the pioneers of the industry have passed over. I make no claim to be an historian, but I think it is worth while putting on record a fact brought to light by Mr. J. A. Durie. He tells us that whereas the first we hear of Mr. C. F. Delfos and the Pretoria Town Lands was in 1917, the latter was actually active in the matter of obtaining metal from the ores thereon at least ten years before. A parcel of Pretoria Town Lands ore was brought to the Old Rand Foundry about 1906 or 1907 and an attempt was made to reduce it in one

of the cupolas. The product seems to have resembled quite closely the lump reclaimed from their clay furnace by the primitive natives (Vhavenda) who carried out smelting at the Empire Exhibition, namely, a lump of slag, carbon and iron silicates plus a very little leavening of metallic iron of very low carbon content. Anyhow, nothing conclusive could be gathered from the work done in Ferreirastown, and a consignment of the same ore was next sent to the Continent where iron was successfully reduced from it. After this there was a quiet period of a number of years before Mr. Durie and his fellow founders got in touch with Delfos once more, pointing out the high price of iron and the urgent need for local supplies. It can scarcely be said that this was the factor leading to the Pretoria experimental blast furnace, but there is no doubt it had a very definite influence in the matter.

I am afraid that in mentioning the chief topics discussed by the founders I only mentioned those which they were prepared to talk about when together, but omitted one which each, individually, has been prepared to discuss with "outsiders" at all times and seasons, namely, price-cutting and its evils! Perhaps I am out of date—perhaps since boom conditions have arrived you are not so concerned with the iniquities of the small-worker, the backyard establishment. Perhaps the backyard shop has blossomed out into something more pretentious. However this may be, I make bold to suggest that we heard more about backyard competition than the subject deserved. The simple work which the small-worker could do in his backyard has been claimed as the bread and butter lines of the large foundries. Might one not take the view that if these so-called bread and butter lines are so simple as to be produced by a small-worker in a backyard, it is incumbent upon the bigger establishments, with their wider resources, to develop a higher class and type of foundry work beyond the reach of these embarrassing small-workers?

### Founding is an Art

Hitherto, I suggest, iron founding in particular has been an art, and an empirical art at that. It is one of the last sections of engineering to have the inquiring hand of the scientist laid upon it. May I add that as far as I can see, we have not yet paid much heed here to the remarkable advances made in the production of high quality irons in Europe and America, and I would like to quote an editorial in a recent issue of THE FOUNDRY TRADE JOURNAL. [Mr. Nimmo Dewar then read the leader which appeared in the issue of February 4 on "The Field for High Quality Irons."]

### High Duty Cast Irons

The technical matter in this abstract sounds fine, but to a Scotsman the last sentence—"they require a considerable amount of knowledge and experience to make, but there is little doubt that enterprise shown in their manufacture will have its reward"—is the most appealing! I must say that to my knowledge the various processes mentioned are almost wholly foreign to this area, and I consider the quotation very apposite as leading up to a few words on the work facing the South African Branch of the Institute of British Foundrymen.

First I would mention everyday cupola and foundry practice, which is rather an art than a science with us at present. Linked with the art in question is the question of labour and its high cost and many restrictions. How to develop our trade to a maximum in face of our special local conditions must be our particular study.

### Valuable Contacts

Do not think that I am suggesting that iron founders here are out of date and hitherto content to remain so. Many pay periodical visits overseas and take a busman's holiday at as many foundries as possible, but while one can pick up a practical tip or wrinkle here and there, it is scarcely possible to gather up a new technique and transplant it to this country, especially as it is the staff and not oneself who will have to carry it out. In other words, one cannot help feeling that to get effective results in a new and better technique it is necessary to import a few key men experienced in the developments about which we shall doubtless hear in Papers read before this Branch of the Institute.

Next it seems necessary that we hear as much as possible about the high-quality irons covered by my quotation just now, and their fields of application, for I cannot help thinking that there is ample scope for development along these lines. There must come a time in the industrial and manufacturing development of a country, this country in fact, when sufficient demand exists to justify the production of malleable. At first, at all events, one establishment would be ample, and it should surely be possible to work up to it on a friendly and co-operative basis.

I feel that our non-ferrous foundry work is already rather well developed, and the same can perhaps be said about steel, but progress overseas is constant, and we must derive great benefit from being in touch with the latest practice. Altogether, in fact, there is a big new field to be explored, and it is for such exploratory purposes that this Institute has been formed. I would like to assure you that as the first President of this Branch I shall do my utmost to establish and develop it in the service and interest of its members.

At the conclusion of his address the Branch-President presented a list of members totalling 41, and advised the meeting that others were awaiting confirmation by the Council.

### Election of Council

A permanent Council was thereupon elected, consisting of Mr. T. Nimmo Dewar (Branch-President), Mr. J. A. Durie, Mr. P. M. Boag, Mr. A. H. Moore, Mr. J. Tonge, Mr. D. M. Davidson, Mr. A. H. Guy, Mr. J. N. Mackenzie.

Discussion then took place on the President's address. MR. GUY, who moved a vote of thanks to him, viewed this meeting as being of the utmost importance to the industry, being the start of organisation on scientific lines. He had been impressed in England when attending meetings of the Institute with the open discussion and spirit of mutual help which existed. Foundry trade was a keen industry of the country, and its scientific development must be regarded with pleasure on all sides.

MR. DURIE welcomed the meeting as signifying that something was at last being done to improve the professional status of foundrymen in South Africa. The industry had struggled from small beginnings when it was called upon, because the country was excluded from the world's markets during the European War. He recalled that twenty years ago, when a Munitions Committee existed, Wright, Boag & Company had made bombs. There was a grim possibility of the industry being called upon for considerably greater tasks in the future. It was well to have association with British foundrymen who had extended a hand of friendship, and in considering the dark possibilities of the future, should war break out, it had to be recalled that a shortage of scrap would be acute. South Africa, however, could, if necessary, do without scrap, since pig was available to meet the position from its direct use, being dependent only upon the question of mixture.

MR. D. M. DAVIDSON said he had derived a good deal of pleasure from the address. The inauguration of the Branch would be welcomed in London, particularly by Mr. V. C. Faulkner, who was so enthusiastic for the furtherance of foundrymen's interests. An employer and employee were associated in the Institute, and in his view this was a particularly pleasing feature of the undertaking. In the past the industry had had to struggle along with all sorts of scrap and its scientific side had been neglected. It now looked forward to real progress, and he was of opinion that the industry was bound to regard the iron and steel works in Pretoria with considerable pride. He wished particularly to extend a welcome to members of staffs who were present, feeling that mutual problems would be tackled in the Institute in a spirit of co-operation. The Institute, further, was lucky in the choice of its first Branch-President.

### General Discussion

In the course of general discussion following, members were invited to submit Papers to the Council for discussion, the Branch-President indicating that the Council would forthwith start to draw up a programme of work.

MR. J. G. FINLAY, in congratulating the meeting on the formation of the Branch, pointed out that pig-iron prices were stabilised in South Africa, while world prices were rising rapidly. In the last two years the South African Iron and Steel Corporation had been actively engaged, and in the course of the next few months would have two blast furnaces in full production. He felt that contact between the Corporation, as producers and suppliers, and the foundry trade, as consumers, was essential to the well-being of the industry, and trusted that such contact would be maintained through membership of the Institute.

MR. H. HOLDSWORTH, who was an overseas member, suggested that the Council should consider the admission of practical men as Associate Members and not as Associates. The BRANCH-PRESIDENT promised that the Council would give consideration to this point. MR. HOLDSWORTH also suggested that members should have some identity badge. He felt privileged to be present at the meeting and considered that the accomplishments of the industry in South Africa, in the teeth of the considerable obstacles which had faced it in the past, was little short of marvellous.

The meeting terminated with a vote of thanks to the chairman.

## Catalogues Received

**Centrifugal Fans.** Although it contains but eight pages, much technical data is contained in the latest publication (No. 1058 B) of the Sturtevant Engineering Company, Limited, of 147, Queen Victoria Street, London, E.C.4. It covers three main types of fans, having radial paddle blades, forward curved multiblade and backward curved blades, but the performance of the multivane fan is emphasised in this particular booklet. This brochure is of the type one files because of its distinct use in designing plant and obtaining quotations, without recourse to a mass of preliminaries.

**Oil-Fired Furnaces.** The outstanding feature of a new catalogue covering this subject, issued by the Morgan Crucible Company, Limited, Battersea Works, London, S.W.11, is the inclusion of so much worthwhile information associated with the complete exclusion of "frills." The field surveyed is much wider than one would at first imagine, and room has been found in its fifty odd pages to give detailed descriptions of various forms of both central axis and lip axis types of tilting furnaces; lift out; bale out and brazing furnaces, and an important section devoted to auxiliaries. The technical side is handled by the inclusion in each case of "working results," whilst the data dealing with floor space requirements, and the notes on fuel oil are invariably acceptable. The last part of the catalogue is devoted to illustrating a number of typical installations, and from this an impression is given as to the neatness and tidiness that can be associated with the installation of a crucible furnace as a melting medium. This catalogue is available to our readers on request.

# Notes on Sandblasting*

By W. G. MARTIN

As a method of preparing a surface for application of sheet steel ground coats, sandblasting has not in the past been of interest to the large majority of enamellers. Pickling has been the standard method used for cleaning the iron. One important reason for this is that sandblasting, even at low pressures such as 15 to 20 lbs. per sq. in., will warp light-gauge parts. Furthermore, in general, sandblasting is more expensive than pickling, though when sufficient volume of suitable work can be obtained, or with the newer developments in sandblasting equipment this difference in cost may become negligible. The enamelling of cast iron, and the manufacture of large heavy-gauge ware such as tanks has without exception employed sandblasting for the metal cleaning operation. Size of ware alone will in some cases dictate the use of the blasting method. However, with the spread of wet process sheet iron enamelling to sanitary ware and architectural uses, sandblasting will be used more widely.

### When Sand is Used as Abrasive

This discussion will be concerned primarily with sand as the abrasive. For very rough work such as knocking moulding sand from castings, steel grit† and very coarse sand, no doubt, have a place. However, for producing a fine, uniform finish for vitreous enamelling, sand graded to about 40 mesh seems to be the best all-round material. This may be a sharp sand, but it is generally conceded that this material breaks up rapidly and produces much dust. Near Ottawa, Illinois, there is an outcrop of sand in the form of round pebbles, and this material, when washed and graded, makes a very desirable abrasive. The author has always been interested in the fact that when a sandblast unit is cleaned out and loaded with this material, the iron surface cleaned with the first run of these round pellets is completely jagged in appearance under the microscope and there is no sign of the rounded impression that one would expect, and which one sees when steel shot are used. Very high speed motion picture studies of the sand striking the steel would no doubt be most interesting in this respect.

Steel grit is a very fast cleaning abrasive, but is fifteen to twenty times as expensive per lb. as a good grade of sandblast sand. In personal experience the author did not get a satisfactory surface with the usual sizes of steel grit, and it is doubtful whether very small sizes could have been used successfully. The greater weight and sharpness of the steel grit produced a surface which was extremely rough and highly jagged, and blistering and very poor bubble structure in the ground coat was the result. Because sand is continually shattered and removed as dust, it is not likely to accumulate dirt. There is, however, the problem of dust collection and disposal.

### Types of Equipment Available

There are three types of equipment in general use for applying the abrasive to the work. Essentially their function is to impart the desired velocity to the abrasive particle.

The induction system consists of an air nozzle within the abrasive nozzle. When the air rushes out of the air nozzle and passes out of the larger abrasive nozzle, a suction is created which carries the sand with it. This method involves only inexpensive equipment, but the compressed air, which is an expensive commodity, is used inefficiently.

The direct pressure equipment consists essentially of a tank for holding a charge of sand. This tank is held at the air line pressure and the sand drops through an adjustable hole or slot into the air stream flowing through the hose to the nozzle. The abrasive chambers can be made in two compartments, one above the other, with a valve between, and thus will feed sand continuously without stopping to recharge. With a gravity feed hopper above, the charging of sand can be made automatic. Such methods were used at the Smith plant in connection with a battery of twelve pressure tanks supplying 48 nozzles in an automatic machine built to sandblast line-pipe for enamelling.

Quite recently two of the foremost sandblast equipment manufacturers have placed on the market an entirely new type of machine with which to apply the abrasive. The principle of centrifugal force is used to propel the sand against the ware, and great efficiency is claimed for this method. For instance, at 80 lbs. per sq. in. pressure, three nozzles require from one to two hundred horse-power, depending upon the nozzle size, from five-sixteenths to one-half inch. The centrifugal machine is rated to do the same work at a maximum of fifteen horse-power.

The machine consists of a disc on the end of a driven shaft. Replacable vanes of a very hard material are fastened radially to the disc and the sand is fed to the centre of the disc, where it is picked up by the vanes and thrown out against the work. There is, of courre, a provision for directing and guiding the stream of abrasive so that it comes out at one point of the circumference rather than flying out in any direction. No accurate comparative figures are available, but it seems that such a machine should reduce the cost of sandblasting to a point where it would be competitive with pickling, at least for certain suitable types of work.

In the old standard compressed air type of sandblast machine, an operator is required for each nozzle unless some specia! provision is made for automatically directing the flow of abrasive from the nozzle to the work. Sometimes the ware could be placed in, or run through, a cabinet. The operator watches the work through a window while holding the nozzle with his hands and arms projecting into the cabinet, and is usually protected by rubber sleeves and gloves. For other types of ware it is often necessary for the operator to be in the room where the blasting takes place. Because of the sand flying in all directions, it is necessary for the operator to wear a helmet and heavy rubber gloves, and, since the operation is extremely dusty, some kind of a respirator must be used to prevent inhalation of the dust. Filter type respirators have been improved, but for this very dusty job, a helmet or face covering supplied with a stream of compressed air is much more effective. Sometimes the operator is completely dressed in special clothing.

### Silicosis

Silicosis has had considerable publicity of late, and the public is far better informed concerning dust hazards than it has been in the past. However, too much emphasis cannot be given to this disease. The victim receives no warning of his fatal condition until the lining of the lungs have received a large amount of the silica. Since the body has no facilities for absorbing this type of foreign material, sear tissue tends to form over the dust on the lining of the lung. This cuts down effective lung surface, and is proportionately serious. It seems that lungs can handle large amounts of coal smoke and organic material without serious damage, but sharp, insoluble particles in quantities cause the type of irritation which so often results in complete disability and death.

To obtain maximum efficiency with a compressed air propelled sandblast, a number of factors should be properly related. The more important items to be considered are:—(1) Suitable nozzle diameter; (2) nozzle length; (3) throat design; (4) distance of nozzle from work; (5) air pressure; (6) flow of sand; (7) overlaps, and (8) size of sand; (*a*) average in use and (*b*) size and amounts added. Probably in most cases these considerations are disregarded and suitable air pressure and nozzle size are chosen by experience, or guesswork, and the sand flow is simply adjusted until the maximum amount of bluish halo is seen where the sand strikes the work. It is generally conceded that it is more efficient to use low pressures and large nozzles.

It is a personal belief that the size of the abrasive grains used has considerable effect on the quality and working characteristics of the enamel ground coat. The effective size of the grains will be determined by the size of new sand added to the system and the rate of increase of the fineness of the sand in the machine. Effective rate of increase in fineness is a function of several factors, namely:—(1) Amount of new sand added at certain intervals; (2) ventilation of the blasting chamber; (3) average fineness at any time; (4) air pressure at nozzle; (5) hardness of surface being blasted; (6) angle between the blast stream and the work surface, and (7) hardness and shatter characteristics of the abrasive.

### Sandblast Nozzles

Sandblast nozzles have been greatly improved in the last few years. Formerly, white or chilled cast iron was the common nozzle material, and the length and throat design of the nozzle for a given diameter was varied considerably by various foundries. Most cast-iron nozzles become quite badly worn after thirty or forty minutes use at high pressure. There now are nozzles available which are good for from four hundred to one thousand hours of service. These nozzles are made of lead or aluminium surrounding a core of tungsten carbide or boron carbide.

Of primary interest, however, is the relation of the sandblasted surface to the behaviour of the enamel ground coat during and after firing. In the first place, since the sand actually cuts away the surface of the metal, if the sand and air are clean, there will be no films left upon

* A Paper presented to The Institute of Vitreous Enamellers, Mr. V. C. Faulkner presiding. The author is at the A. O. Smith Corporation, Milwaukee, Wisconsin.

† In the United Kingdom the usual expression is chilled iron shot.

the surface. This is desirable because it leaves no question as to type or amount of film or other characteristic of the surface.

### Enamelling Conditions

The roughness of the surface can be maintained to quite a satisfactory degree of uniformity. This roughness is important in a number of ways. The pick-up of ground coat in a dipping operation depends to a large extent on the character of the metal surface. With the enamel in any given average condition, pick-up will increase with roughness of metal surface. Furthermore, it is felt that trouble from slipping and secondary draining will be minimised on a sandblasted surface. A rough surface aids bond in two ways. Due to the "hills" and "valleys," contact area between the enamel and metal is increased—thus the effectiveness of wetting power is enhanced, and it is easy to show that there is considerable mechanical bond between the enamel and a sandblasted surface.

Ground coat fired on a smooth piece of pickled iron in an atmosphere of nitrogen will have practically no bond because there is no chance for the usual oxide film to form between the enamel and iron. Ordinarily, this oxide layer forms by infiltration of oxygen before the enamel melts, and then at maturing temperatures, the oxide goes into solution in the enamel. The addition of the iron oxide to the average ground coat greatly increases the wetting power or bonding of the enamel by the iron. Ground coat fired in nitrogen on a piece of sandblasted iron will have quite good bond because of the interlocking effect of the jagged surface. The best bond results from a combination of good wetting power and a rough surface.

Experiments on the control of the oxidation of iron prior to the fusion of the enamel have shown that the oxidation characteristics of an iron surface is a variable thing. Some areas of the surface oxidise very readily while others show a reluctance to oxidise. In some cases, resistance to oxidation, or a kind of passivity, is probably related to films on the surface. A well sandblasted surface is probably less likely to have objectionable films than is a pickled surface. However, if the surface of the iron is torn too badly and many slivers have been formed, too much iron oxide is likely to be formed, or at any rate there will be too much reaction between the iron and enamel. Blistering and generally poor bubble structure will be the result.

### DISCUSSION

The CHAIRMAN (Mr. V. C. Faulkner) said the term "steel grit" should not be used; the proper term was chilled iron shot. Apparently, grades of chilled shot which were not popular in this country were being used in the United States.

A MEMBER asked if anyone had had any experience of the centrifugal airless blasting machine.

The CHAIRMAN said he had seen them in operation in at least half a dozen factories. He saw at least four different models at the International Foundry Exhibition at Düsseldorf last September, and in general they were a great success.

MR. C. P. STONE stated that he had had thirty years' experience of sandblasting sheet iron, and he rather thought that the author was a little behind the times compared with British practice. Thirty years ago satisfactory results were obtained with sandblasting machines, but on sheet metal one ran the risk of copperheads, and unless one went to a very considerable expense by using fine sand and low air pressure, distortion and, finally, rejects often resulted.

One could spend 10s. on a piece worth 2s. 6d. and produce a satisfactory job, but it was obviously not economically sound. In 1910 machines were made with the sheets running vertically through rollers, and every endeavour was made to prevent the sheet from being distorted, but the result was altogther out of proportion to the cost. It was not wise to adopt sandblasting. The lecturer spoke of the firing of enamel sheets in an atmosphere composed of nitrogen. That was not general, and it might not be economically possible. In this country enamellers desired a clean, heated and oxidising atmosphere.

The CHAIRMAN observed with regard to the utilisation of a different size of grit, that in America they used the finer grades, which gave a market for all the sizes made.

MR. A. L. EDWARDS referred to the application of the "Wheelabrator" in America. At the works with which he was associated they had one which operated on a heavy gauge sheet, 16 gauge or heavier, which was used in the preparation of sheets with a corrugated surface.

MR. STONE said it was on 16 gauge that his experiments were made, but neither the makers nor themselves could make progress.

The CHAIRMAN observed that progress had been made since then.

A MEMBER asked whether it was to be understood that one of the advantages of sandblasting over pickling was that greater adhesion would be obtained.

MR. STONE remarked that in all circumstances he would choose the latter process.

A MEMBER said that reference had been made to the difference between American fine shot and English coarse shot. That was due to the fact that there were very few really modern sandblasting machines in this country. The usual variety would not take the fine shot. All American plants used fine shot and obtained faster results, but machines in this country were not constructed to take the fine shot and plates had to be sandblasted as well as pickled. A good result could not be obtained unless they were sandblasted afterwards.

MR. STONE pointed out that he was concerned with rather a heavy gauge (16) metal which did help to prevent distortion, but from an enamel adhering point of view and general finish, he preferred not to use a sandblast.

The CHAIRMAN asked whether any trouble arose from hydrogen swells after pickling such as had been noted in connection with the tin-plating industry.

MR. STONE replied that, if there was any inclination to lamination, the surface became swollen by the hammer effect of blasting, and a large blister would result.

MR. A. G. READ said that sandblasting had been put forward as a substitute for, or in opposition to, pickling. This would be possible in connection with the most expensive part of the work, for example, large tanks, sinks, etc., but pickling could not be supplanted by sandblasting for cheap ware.

A MEMBER said he would like further information about controlled oxidation in a furnace where there was a considerable amount of oxygen.

MR. STONE stated that the more oxygen one had (again considering the expense), the better was the result. The copperheads were caused by the inability of the enamel to absorb the iron oxide, which was always formed during ground firing. The enamel should be able to do that if good results were to be obtained, particularly when used on steel; dirty pickling very often gave the same defect.

MR. EDWARDS said he did not believe that the author of the Paper would consider sandblasting feasible for light-gauge hollow-ware.

# A Résumé of Some Studies on Sheet Steel Ground Coat Enamels*

By R. M. KING

### Adherence

Several years ago a project was started in the department of Ceramic Engineering of the Ohio State University to study the nature and causes of the adherence of vitreous enamels to metals. It was decided first to make an effort to determine the *rôle* of cobalt oxide as an adherence promoting agent in present day commercial sheet-steel ground coats. This subject has received sporadic attention by a few German and American ceramists and chemists over a period of several years. It was felt, however, that a more thorough and persistent study would lead to a better understanding of this problem. Space will not be given to a bibliography of this subject, but those interested are referred to one of a series of articles of the July, 1934, issue of the Journal of the American Ceramic Society.

In order to avoid repetition in describing the results of the Society's experiments, the term "commercial ground coats" will be used to designate cobalt and/or nickel-oxide-bearing sheet steel ground coats. It was decided to use every possible technique to determine what is present and what takes place at the metal-enamel interface. To this end, the author has employed chemical analyses, the metallographic and petrographic microscopes, the X-ray, and specially devised techniques. He has also used certain well-known and other less known methods to obtain a numerical evaluation of adherence, but these were not very satisfactory. It might be stated here that the lack of a satisfactory method for determining the numerical value of adherence is a serious handicap to such studies.

The following is a brief outline of the previously existing theories, postulated to explain the action of cobalt oxide:—

(1) The formation of an intermediate third and bonding phase at the enamel-metal interface:—(*a*) A phase of cobalt metal; and (*b*) a phase of iron oxide.

(2) A preferential solution of the iron by the ground coat, thus roughening the surface and enabling the enamel to "key" itself in.

(3) The cobalt oxide aids in adjusting the coefficient of expansion of the enamel to that of the metal.

If a layer of cobalt were plated out, it is likely that adherence would be decreased, as it is well known that commercial ground coats will not adhere to cobalt. Personally made X-ray studies have shown that FeO and $Fe_3O_4$ are present at the interface when the ground coat is fired in air and also when fired *in vacuo*. However, in the latter case there is no adherence, but the enamel separates cleanly from the steel immediately upon cooling. This indicates that these oxides are not associated with adherence. On the other hand, personal metallographic and X-ray studies have also shown that a metal is precipitated at the interface in tenacle-like or dendritic form when a commercial ground coat is fired in the usual manner. However, when the same ground coat is fired *in vacuo*, this dendritic formation is not in evidence. Furthermore, as stated above, there is no adherence. This suggests that the dendrites have something to do with adherence.

* A Paper presented on behalf of the Porcelain Enamel Institute to The Institute of Vitreous Enamellers, Mr. V. C. Faulkner presiding. The author is Associate Professor of Ceramic Engineering, Ohio State University.

While there is no direct proof of this, there is some indirect evidence, *viz.*, that they have always been found associated with adherence and have been found absent when adherence is lacking.

### Commercial Difficulties

This metallic formation is difficult to see in a commercially-fired ground coat unless a polished section is highly magnified. However, when a piece of steel is buried in a crucible of cobalt-bearing enamel and heated for several hours at regular firing temperatures, dendrites may be easily seen. While this is an exaggeration of commercial firing conditions, it is thought that results of this procedure indicate the direction in which the reaction is proceeding in the absence of overfiring conditions, that is, under conditions which prevent the excessive formation of oxide. These results have been supplemented by experiments in which a commercial ground coat has been heated at its maturing temperature for 10, 20 and 40 minutes in iron crucibles. Photomicrographs of sections of these crucibles show that dendrite growth is proportional to the time.

The most puzzling finding in regard to this metallic formation is that it consists of iron rather than cobalt or nickel. However, under special conditions, described later, the author has obtained cobalt dendrites. Although there is some evidence to show that both iron and iron cobalt alloy high in iron are precipitated, the fact remains that the precipitated metal is predominately iron. This has given rise to much speculation, and many experiments have been carried out to determine how it is possible for iron to be taken into solution and reprecipitated. This is equivalent to iron precipitating itself from solution. The answer to this question is not known at this time.

Studies of metal precipitated from enamels high in cobalt oxide (2.5 to 10.0 per cent.) and heated to 1,370 deg. C., in iron crucibles, show that alpha iron and alpha and beta cobalt are present. Nickel was also precipitated, if its oxide was included in the enamel. It has been assumed as a working hypothesis that these metallic dendrites are a factor in adherence, and an endeavour has been made to apply it to the solution of some practical problems.

### White Ground Coat

An ideal of all enamellers is to produce a satisfactory white ground coat for sheet steel. A search was made for a white oxide which would produce a dendritic formation when incorporated in a ground coat base. It was found that tungstic oxide, molybdic oxide and antimony trioxide would do this. A fairly satisfactory white ground coat was produced by incorporating both antimony and molybdic oxides in a colourless ground-coat glass. When this enamel was fired on sheet steel, antimony, molybdenum and iron were precipitated in dendrite form at the enamel-metal interface.

Another practical problem in this connection is the control of rate of formation and size of the dendrites. The rates of heating and cooling are known, particularly the latter, and are factors in size control. Hence, the firing of ground coats in continuous furnaces and in box-type furnaces may produce differences in adhering characteristics of an enamel. Some experiments to determine the effect of heating and cooling have been carried out, but with inconclusive results.

In summing up the special case of cobalt-bearing ground coats, one can say:—

(1) That iron oxides and metallic iron are precipitated at the interface; (2) adherence is associated with precipitated metal in all cases, but not always with precipitated oxides; and (3) that roughness of surface or differential etching are not important factors in adherence; (4) coefficient of expansion is not a direct factor in adherence. A high difference in coefficient of expansion may cause the enamel to separate from the steel, but a small difference will not of its own accord bring about adherence. Commercial ground coats are known to have coefficients widely different from the steel.

### Reboiling

Another ground coat problem that has given the American enameller much concern is the defect known as "reboiling." This has received considerable attention in Ohio University laboratories. Prof. J. O. Lord has carefully investigated the findings of various American laboratories on this problem, and has defined reboiling as follows: "Reboiling is a sudden appearance of blisters on the surface of a fired ground on sheet enamelling iron that may take place during the heating period on subsequent firings, the blisters disappearing again as the time of firing is extended." In practice, reboiling is revealed as "black specks" which show through the superimposed cover coats.

The most elusive factor in connection with reboiling is its intermittent recurrence and disappearance. Ground coated pieces of sheet steel have been reheated as many as 25 times before the "blisters" ceased. The pertinent facts so far established are:—

(1) Reboiling is peculiar to ground coats containing nickel and cobalt oxides when applied to steel. In other words, it is a characteristic of the system: commercial ground coat—commercial steel—oxygen. With a given ground coat, the reboiling tendencies of the enamel-steel combination will vary with the steel, although the latter may be first quality enamelling stock. With a given steel, reboiling will vary with the amount of cobalt and nickel oxides in the enamel and with the relative proportions of these oxides.

(2) If the ground coat be fired *in vacuo* by a special procedure, reboiling will not take place on subsequent heating. Thus, firing *in vacuo* seems to accomplish the same results as 20 to 25 reheatings.

(3) Reboiling apparently takes place when metallic precipitates are formed at the interface. It might be stated here that the white ground coats mentioned above also showed reboiling tendencies. Hence, reboiling, metallic precipitation and adherence are apparently related.

## DISCUSSION

The CHAIRMAN said the Paper first asked for a test to establish a numerical value for adherence, and in that connection he could not see why some sort of bend test should not be made possible whereby one could get the degree of bend before the enamel cracked.

MR. C. P. STONE said that Prof. King, if present, could be asked quite a lot of important questions. He had mentioned the kind of apparatus all enamel chemists would like to possess, and while the analyses from the X-ray machines were not extremely accurate, they were very useful. Theoretically, many factors might be proved to be wrong, but those engaged on the practical side were successful with them in enamelling English low grade steel which in America would be called non-enamelling metal. The idea was prevalent that one could bend enamel freely, but actually enamel was glass, and one could only bend it very little, according to the thickness of the coat, without cracks showing. Enamel did not bend as much as some people tried to make one believe. He had been amused at demonstrations of wrapping it round three-inch pipes cold, for white enamel could not be bent.

He noticed the author did not recommend the use of nickel and cobalt together, and he would like to ask Prof. King why, as experience had shown the reverse. It was an established fact that nickel above a definite percentage would cause copperheads. It brought them up particularly with the second firing. He also gathered that Prof. King stated that if cobalt were added to almost any enamel, a ground coat would be obtained which would be more or less suitable, yet it was known that the addition of cobalt to any enamel was unsuitable. It was possible to make an enamel for almost any application, and he was rather surprised to note that the author did not mention that. He had mentioned steel, but was he referring to ordinary, or common steel? The critical temperature at which all metals started to recrystallise had an effect upon the number of firings one gave ordinary steel. Five firings were usually the limit, and, of course, the temperature at which the enamel was fired had to be very carefully controlled. English low-grade steel usually had a critical temperature from 875 to 910 deg. C., and some people would put steels into a temperature 950 deg. C. and wonder why they encountered trouble. This was due to crystallisation, but if they observed the critical temperatures and used the correct ground coat, low-grade steel could be utilised. If a high-grade job, which required a very good finish was wanted, they had to use a little better-quality steel.

Prof. King had confirmed his (Mr. Stone's) contention referred to in his last Paper, that rough surfaces were immaterial and were not essential to a good enamelling result. The author had had a lot of experience in connection with enamelling to be able to say that. It was a pity that he did not give a little more information about refractory values and coefficients. Reboiling and blistering were related to the critical temperature of the metal and enamel used.

Mr. Stone finally observed that 2½ per cent. of cobalt was very extravagant. Evidently Prof. King had plenty of money available.

MR. A. L. EDWARDS said that the main point of the discussion showed a dissimilarity between the practical point of view and the highly theoretical. They had been listening to a Paper by a theoretical man, and it was common knowledge that the theorist's conclusions were not invariably established by those in practice. Final results were governed by individual practices and circumstances. When the author spoke about the use of certain atmospheres and certain analyses of cobalt, they should look at the matter from the point of view of the man in the laboratory.

MR. W. THOMAS said the Paper was a scientific attempt to get at the real cause of adhesion, and the other problems such as reboiling, and what was done in the laboratory to-day, would in five or six years become factory practice when the enameller was a little more scientific and the value of research work in laboratories would be more appreciated.

A MEMBER asked a question regarding "Armco" iron. He believed that "Armco" enamelling iron had a more open surface than others, and he asked whether that had any connection with the tenacity of the ground coat, and had that open surface a characteristic which was aimed at by the manufacturers or was it purely incidental in its manufacture?

MR. EDWARDS explained that "Armco" was a pure iron, and consequently in hot rolling took on a roughened surface. This surface was intentionally developed in the process of manufacture to a degree which would ensure the utmost tenacity of the enamel. Prolonged research and the co-operation of the practical enamellers had enabled them to establish the matt surface familiar to the enamelling industry, assuring a tightly adherent bond of enamel superior to that attainable with a "slick" surface.

A MEMBER: In that case there is no need to sandblast.

MR. STONE said that thirty years ago they used charcoal iron. Unfortunately, charcoal iron had only one grain, and it was enamelled

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# Millroom Practice

After Mr. B. B. Kent had presented his Paper on this subject to the Northern Section of The Institute of Vitreous Enamellers, an interesting discussion was opened by a MEMBER, who said the lecturer had referred to daylight, gaslight, electric light, and many other types of artificial lighting effects, but he, personally, had found that the best plan to adopt was to have two standard colours. If a special green had to be matched as closely as possible, the type of oxide used would have certain idiosyncrasies; it might have a tendency to burn blue, greenish or grey. In such a case it was advisable to have two standards, one being the standard required to be matched and the other being the limit on which the colour depended. Between these two limits it would be possible to use any colour.

The best plan was to soak the scrapings for a short time, sieving again before beginning to re-grind the enamel. He was puzzled by the fact that if an enamel was ground for five hours there would be a residue of 12 units, and if it was ground for 4¾ hours, and then ground for another 10 minutes, there would be three units. He had never experienced this himself. He had usually found another hour would bring it down one or two units.

Ageing would liberate any air in the enamel, but the true function of ageing enamel was to soak the clay and thoroughly saturate it. Clay, when dried, was not dispersed throughout the mixture as when it was wetted. Sometimes a good plan was to wet the clay, because then it would be dispersed more uniformly.

Mr. Kent had stated that if trouble was experienced in obtaining the correct consistency of ground coats, it should be left to the operator to deal with it. Ground coats, however, were the basis of enamelling, and the operator did not understand anything about consistency or the amount of soluble salts dissolved from the frits. If borax was added, it would lead to many complications, and, amongst other things, it might cause pitting.

MR. KENT said that reference had been made to speeds of grinding down enamel. In his own plant the mills were run at about double the recognised speed. The makers stated the speed at which the mills should be run, but if they were operated at this speed probably twice the number of mills would be required.

The milling times stated in the Paper might vary by five minutes. He thought he had stated there was a change from 12 units to 3 units in 10 min., but it might be 12 to 4 in 15 min.; towards the end of a batch the grinding was very much quicker.

Regarding the ground coat, unfortunately his own plant was exceptionally hot and evaporation took place. The dipper only added water to thin the mixture a little.

### Mill Speeds

MR. J. H. GRAY referred to the running of mills at double the specified speed. Although Mr. Kent had seen this done in actual practice, he (the speaker) did not consider it would be economical. He could not imagine a 200-lb. mill running at about 60 revs. per min. without the lining being smashed in a very short time. Whether it was economical for producing the wet enamel he was not sure; but he was certain it was not economical as far as maintenance of the mills was concerned.

He wished Mr. Kent had spent a little more time on the practice of using the scrapings. It did not matter to what plant one went, they always seemed to have some different method of treating the scrapings. Some enamellers did not use them at all, they had them refritted, and he agreed that refritted material gave good results. In one case the scrapings were emptied into a large cement-lined wooden tank overnight, water was added, and at the end of the week the water which had risen to the top was taken away and a certain percentage of clay added—in this particular case 1¼ per cent. Fresh water was then added, and the scrapings were mixed with the new enamel prior to being emptied from the mill.

### Utilisation of Scrapings

MR. KENT said that, if enamel was not overheated, perfectly good results were obtained. Scrapings always caused a great deal of trouble, and at his works there were used up to 50 per cent. They were collected, watered down, and, after being put through a screen and separator, they were milled with the enamel for about 20 minutes.

### Fineness Standards

MR. H. BRADLEY referred to the fineness of enamels according to the standard set down, and said that in his experience two men could take the same type of enamel and produce an entirely different unit residue. The two differences in their procedure were the shaking and the amount of water allowed to pass into the sieve while washing. Had Mr. Kent considered any standard way in which the enamel should be washed into the 150-mesh sieve when preparing it before drying?

With regard to ageing of enamels, there was very little difference between using an enamel one hour after it left the mill or after three days. Had Mr. Kent ever determined at what temperature enamel should be used? He had had some enamel tested for fineness, and one man's test had shown 15 units, whereas his own result was 8 units. In his opinion there was too great a difference in the methods of testing enamel. It would be quite satisfactory if one man always did the testing, for then the enamel would have a definite consistency. If, however, someone else said the result was either too fine or too coarse, it would upset the theory that the right method was being pursued.

### Ageing Enamels

MR. KENT agreed that the fineness test was a little difficult to perform, but it was worth doing carefully. One man should always do the tests, and if he made a slight error once, he would probably do the same every time. Trouble was usually caused through not washing carefully, letting the water rush out, and splashing some of the enamel on to the sides. There should be a constant, but not very fast-flowing, stream of water. Very accurate results could then be obtained. When pouring into a little tube, a small funnel should be used to prevent spilling.

Certain enamels, such as an ordinary mottle, were not affected by ageing, but when using a delicate colour, there were variations if it was taken straight from the mill. The consistency varied because, for one thing, there was a certain amount of entrapped air in the enamel. Occasionally, there were little chokes on the spray guns, but he would not say that ageing was an extraordinarily difficult matter in general commercial work. Ordinary room temperature was customary, but no thermometer tests were made. The enamel was not used when it was hot.

If one was testing enamels that were not sufficiently ground, say, 25 units, lumps of enamel might be held back on the 150-mesh screen. When it was poured into the little tube the residue would not settle owing to the presence of such lumps of enamel. There might be three or four pieces of frit that were at, say, 25 units. The test was used generally throughout the American plants, and he believed it originated in the U.S.A.

### Defects through Lack of Ageing

A SPEAKER said the ageing of cast-iron enamels was not so important, because they contained only about 4 per cent. of clay. They were soft enamels which fused readily, and gave a smooth glass-like surface. Sheet-steel enamels were considerably harder, and if they were not aged sufficiently there would be tiny pinpoint impressions over the surface, which did not occur with cast iron.

There were two alternatives with regard to the determination of the fineness of enamels. If it was desired to determine fineness by the ordinary 50 m.l. method, it was desirable to obtain an enamel which was always the same, so that 100 m.l. would flow through a certain-sized orifice in a certain number of seconds. The best method of all, perhaps, was to take not 50 m.l., but the dry weight of enamels.

MR. KENT agreed that it was more important to age sheet steel enamels.

### Management Changes

MR. J. H. GRAY remarked that Mr. Kent had stressed that control in the millroom was essential, and it might be of interest to those present to know that there was a tendency in the trade to appoint an efficient man to take charge of the millroom who was responsible to the works management and not to the enamelling shop superintendent. Previously, the enamelling shop superintendent, being pressed very hard by the progress department, was inclined to instruct the millroom superintendent to unload a mill even when the enamel was not correctly ground down.

Owing to the pressure being put on the superintendent, he did not allow the millroom sufficient time to match colours correctly. Before the new system was put into operation, it was found that the enamelling shop superintendent was really governed by the progress department, but in the new scheme quite a number of difficulties were overcome, and it was found that results were very much more consistent. The millroom superintendent did not go to the works manager to see that the enamel was milled correctly, for he was fully qualified to run the millroom from every point of view.

### A Poor System

MR. KENT could not agree with the mill man being responsible to the works manager. It might be satisfactory if the works simply consisted of an enamelling plant, but in many works the enamelling plant was only one section of the works. The works manager might be several hundred yards away on another job and he would not want to be frequently disturbed. Mr. Kent thought the control should start at the other end. Everyone in the works should be instructed in the particular work he had to do, and there were no short cuts. It was entirely wrong to chance an enamel not being properly milled because it was desirable to speed up production; in the end production would be slowed down. Ultimately, all the operatives were responsible to the works manager through their immediate superiors.

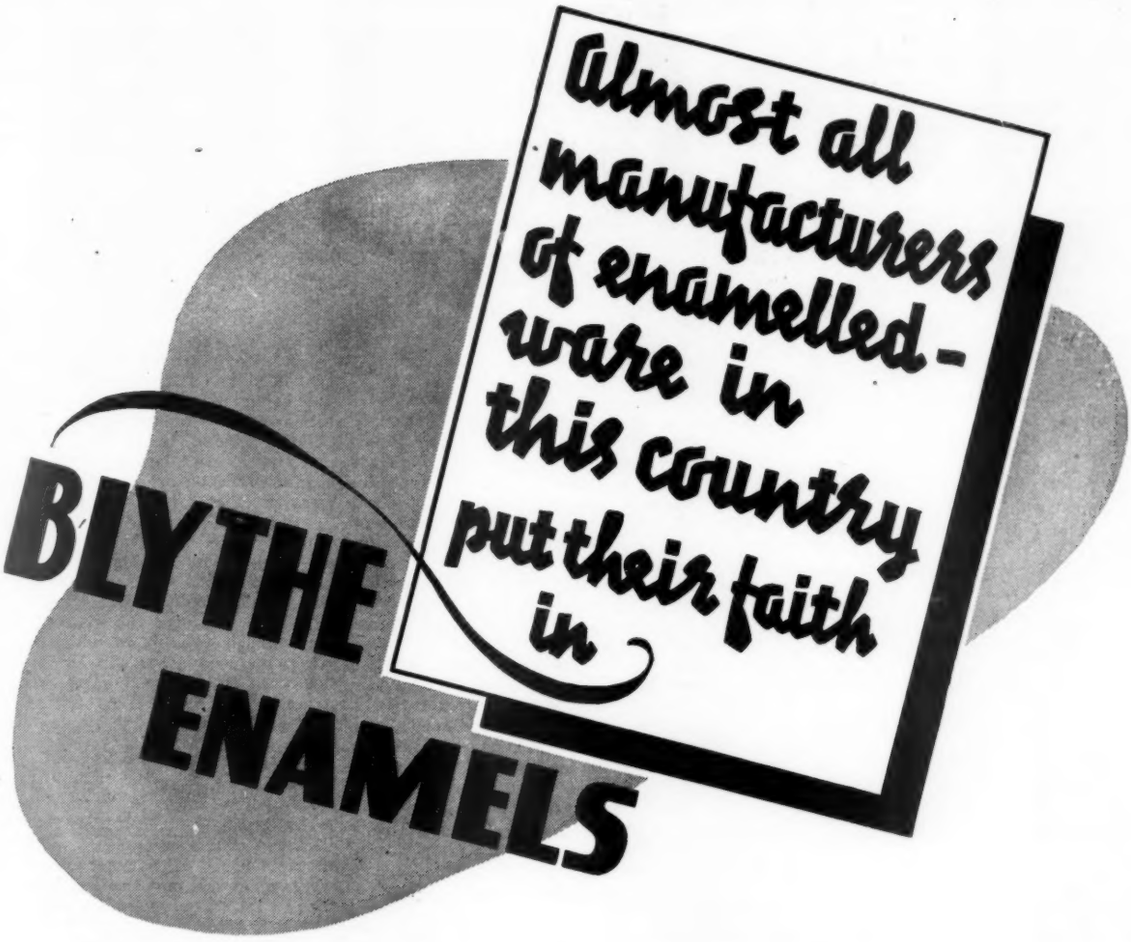
### Mill Design

MR. T. J. MCARTHUR said the reason why designers did not supply mills with a long or high standard or bracket, and why mills had to be imbedded in concrete slabs was sometimes stated to be that if the mills were mounted on very high standards or brackets the vibration caused them to tear loose from their foundations.

MR. KENT said that a standard should conform to a certain specification. If the standard was 2 ft. long and the section of the iron was ¼ in., then if it was made 3 ft. long it should be ⅓ in., and if 4 ft. long ½ in. The bracket could be made to the correct height by proportioning it correctly.

MR. MCARTHUR observed that cost had to be considered, and, at the same time, it would

(*Concluded on page 378.*)

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B 5

require an unwieldy structure of cast iron to support a 1,000-lb. mill. Two brackets would be needed to keep it embedded in the floor and to keep it a sufficient height to unload easily.

Mr. Kent said he was referring more particularly to the 50-lb. mill. If A quoted for a mill with short legs at £25, and B quoted £3 more for the correct length of legs, then B would probably lose the order.

### Acid-Resisting Enamels

Mr. H. Jukes asked if the weight of 38½ ozs. to the pint applied to acid-resisting enamels or to soft enamels.

Mr. Kent said he could not give the figures for acid-resisting enamels, because they differed.

A Member said that with the latest frits about 50 per cent. of water was used, with ordinary sheet steel enamels 40 per cent., cast iron enamels about 30 per cent., and stainless enamels about 30 per cent.

Mr. J. H. Gray thought that the most important point was whether the enamel was being pressure or gravity fed. He had known of a cast iron soft enamel which was slightly set up and sprayed at 34 ozs. per pint. This enamel was gravity fed. On the other hand, he knew of an instance where similar enamel was pressure fed, not set up, and supplied to the sprayers at 40 ozs. per pint.

Mr. Kent said that the conditions varied so greatly that a figure could not be stated.

A Member asked to what kind of enamel the figures of 35 or 38 applied.

Mr. Kent replied that they were ordinary cast iron enamels.

### Loss of Gloss

Mr. W. E. Hiller asked whether, in the case of mills operating at twice the normal speed, it was found necessary to vary the load in order to prevent the pebbles or balls, whichever were being used, grinding away so much of the porcelain lining as to cause some of the gloss of the enamel to be lost when it was being fused.

### Rapidly-Run Mills

Mr. Kent said that no useful purpose was served if the balls were held to the surface by centrifugal force. He thought the loss of gloss was mainly due to overheating.

Makers usually advised quite a slow speed for the mills, whereas they could be run at considerably higher speeds provided they were controlled carefully and the enamel was not allowed to be overheated. In the case of some very large mills in America, the smallest being 1,000 lbs. capacity, water was gushing over them and they were kept quite cool. It was stated there was no trouble as long as the temperature maintained was that of the working temperature of the room.

Mr. H. Bradley inquired if, in the speeding up of the mills, the weight of the pebbles or porcelain balls was increased accordingly, or if the original weight was adhered to.

Mr. Kent said he had stated a figure of 45 per cent. of pebbles, which he believed was on the high side, and 30 per cent. of frit. This was probably loading the mill fuller than was recommended. With mills running at normal speed he would say they should be loaded up to 65 per cent. capacity; if running faster they should be loaded up to 75 per cent. capacity.

The Chairman (Mr. W. H. Whittle), closing the discussion observed that, with regard to the heat of the enamels, some people not only swilled the ground coat, but also the whites and colours. Others, of course, sprayed more than they swilled. Personally, he ground considerably longer than Mr. Kent did, but that was a question of the mill capacity. He advocated grinding colours as finely as possible.

On the motion of the Chairman, a vote of thanks was accorded to Mr. Kent for his interesting lecture.

# American Vitreous Enamelling Practice*

By A. L. Edwards.

In making these remarks the author wishes to acknowledge data from "Better Enamelling," written by Geo. P. MacKnight; a speech by R. A. Weaver, President of the Ferro Enamel Company; and also publicity data from the American Rolling Mill Company. As is well known, the Porcelain Enamel Institute in America is a similar organisation to The Institute of Vitreous Enamellers in Great Britain, and in America they have divided their activities into the following sections: administrative; market research; industry; trade and consumer contact; technical research; production control and advertising and sales promotion.

The function of the administrative section of the Institute briefly is to co-ordinate all of the activities of the organisation and to co-operate with all sections, synchronising their efforts toward the ultimate goal of strengthening and advancing the vitreous enamel industry. Other administration jobs are those protecting the industry's interests against unfair competition; interpretation of legislation affecting Institute members; service and consultation to and with members and members' customers, who are prospective users of porcelain enamel.

The market research section compiles statistics on porcelain enamelling applications, presents bulletins which give the enamelling executive a *résumé* of market information that is useful, and presents other data on general business and industrial activities which are of interest to the member. Surveys are also made of new products which are competitive to the enamelling industry.

It is the work of the industry, trade and consumer contact section to promote the use of porcelain enamel through contact with manufacturers, retailers and consumers. This is effected through department store demonstrations, before sales and industrial group meetings, as well as exhibitions at trade shows and conventions.

The technical research section, which is comprised of committees representing the best technical minds in the porcelain enamel industry, co-operates with the U.S. Bureau of Standards and other scientific organisations in America. During the course of the year the following publications have been distributed and most members are familiar with them:—"Handbook on Design of Metal Parts for Porcelain Enamelling, No. 1"; "Tentative Definitions of Porcelain Enamel Terms"; and "Reflectance Test for Opaque White Porcelain Enamels."

Prof. R. M. King, one of the Institute's technical advisers, has prepared a survey which will eventually be published as a handbook on the enamelling of cast iron. Dr. A. I. Andrews of the University of Illinois (whom it will be recalled published a book entitled "Enamels" in 1935), is also an active member of this section of the Institute. One of the most active and profitable sections of the enamelling industry is the advertising and sales promotion section, which is responsible for advertising campaigns in trade Papers, also for the distribution of educational booklets by a direct mail. This group is also responsible for promoting general development for new uses for porcelain enamelling.

Within the past twenty-five years there has been a tremendous growth in the popularity of porcelain enamel as a permanent, rust-proof, and colourful finish for many products. The economic justification for porcelain enamel is demonstrated by its steady growth, even during periods of depression, and in spite of competition with such fine materials as stainless steel, copper and aluminium. As the use of porcelain enamel has increased the quality has improved and new technique has been developed which has placed under control enamelling problems which a few years ago remained unsolved.

Acid resisting enamels have been developed, new radiant tube type furnaces are being introduced and the industry is visualising a wide field of opportunities for its product which should give great impetus to the British enamelling trade. One outlet which it is thought will be developed to a large extent in the future is the architectural use of porcelain enamelled panels. In America the use of porcelain enamelling in architecture in 1931 amounted to practically nothing, while in 1935 it accounted for over a million dollars' worth of sales and it is predicted that in five years' time this field alone will be doing almost as much business as the entire American enamelling industry is doing to-day.

Shop fronts are being renovated with vitreous enamelled panels and, in fact, whole buildings are being reconditioned by panelling the exteriors with vitreous enamel. Not only are old buildings being thus refreshed, but also new structures are being made with vitreous enamelled exteriors. For example, a new research laboratory is being constructed at the present time by The American Rolling Mill Company, and it will have 600 lineal feet of porcelain enamel side wall, enamelled on "Armco" ingot iron, cream coloured with contrasting decorative pilasters and bands of stainless steel. Between the pilasters will be broad areas of glass block in which horizontal steel sash with clear glass will be set to accentuate the sweep of the building. This air-conditioned structure will provide an area of 41,900 sq. ft. and will house more than one-hundred offices, laboratories and conference rooms, where every phase of metallurgical research and testing will be carried on, including special departments for investigation work in porcelain enamelling.

The development of modern homes made with vitreous enamelled panel exteriors is well known and it is reported that definite sales progress is being made with this new and revolutionary type of structure. Porcelain enamelled plumbing-ware made from sheets has become generally accepted in America and should give rise to an important development of similar nature in this country. Another product which is not so widely exploited in Great Britain as in America is the electric washing machine, most of which are equipped with vitreous enamelled tubs. It is quite conceivable that this might mature into an exceedingly important product in this country. These are a few of the many avenues of opportunity that lie before the industry which should inspire confidence and optimism for this important and progressive trade.

* A Paper read before the Southern Section of The Institute of Vitreous Enamellers, Mr. V. C. Faulkner presiding.

## DISCUSSION

The Chairman said the Paper contained an appeal to manufacturers not already members to join the Institute, but he did not think that the Paper lent itself to discussion.

Mr. B. B. Kent said he thought he could claim to be the first English member of the Porcelain Enamel Institute of America, and he strongly recommended others to join. The membership fee was quite a nominal sum, and one received magazines, statistics and trade bulletins. He would also like to mention that he had on hand about 300 copies of "Handbook on Design of Metal Parts for Porcelain Enamelling," which he was distributing on behalf of the Institute; these could be obtained from him at 1s. each, post free.

Mr. Alex. B. Kent moved a vote of thanks to Mr. Edwards for reading the Paper. The vote of thanks was carried, the Chairman remarking that Mr. Edwards had been very kind in dealing with matters as he had relating to his own country. He hoped that he was enjoying his stay in England and would remain with them for a long time.

Mr. Edwards said he appreciated very much the honour of reading the Papers. If there were any further questions, perhaps they could be sent to him by letter.

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# The Week's News in Brief

## Trade Talk

THE STRIKE at the iron foundries in Sydney, Australia, which has lasted seven weeks, has been settled.

BABCOCK & WILCOX, LIMITED, have opened a new club in connection with their Dumbuck Works at Dumbarton.

SMITH'S DOCK COMPANY, LIMITED, Middlesbrough, have secured an order for a 3,800-ton oil tanker from the Anglo-Saxon Oil Company.

WILLIAM CUMMING & COMPANY, LIMITED, of Glasgow and elsewhere, are granting their employees a day's holiday with pay for the Coronation.

THE MARSMAN COMPANY, of Manila, Philippine Islands, are negotiating for copper mining rights in Java. This company has recently started the mining of chromite on a large scale.

WHITE'S MARINE ENGINEERING COMPANY, LIMITED, Hebburn-on-Tyne, have received an order for the engines of a 9,000-ton steamer, to be built on Wearside, for Mr. G. Nicolaou, of London.

MEMBERS OF THE Edinburgh, Leith, and District Ironmongers' Association, which was resuscitated at the end of last year, visited the works of the Falkirk Iron Company, Limited, on April 28.

A WOLVERHAMPTON FIRM is reported to have leased to Blaina Tin Works in South Wales for the purpose of converting them into an iron foundry for the manufacture of lamp posts, letter boxes, etc.

A £55,000 CONTRACT has been secured by Clarke, Chapman & Company, Limited, Gateshead, from the Slough Estates, Limited, for the supply of two high-pressure water tube boilers complete with auxiliary plant.

A TRADE DELEGATION from Russia is to visit Scotland during May to discuss with firms and business organisations proposals for new contracts. The delegation will visit works and shipyards where work is likely to be placed.

AT THE ANNUAL GENERAL MEETING of Albion Motors, Limited, it was announced that cuts in salaries imposed during the depression of two years ago are to be restored in full, and employees are to have increased holiday bonuses.

THE PNEUMATIC TOOL and air compressor departments of Sir W. G. Armstrong, Whitworth & Company (Engineers), Limited, which are to be transferred from the Scotswood (Newcastle) works to the Close Works, Gateshead, are being considerably extended.

SHORT BROS., LIMITED, of Sunderland, have received an order for two 9,800-ton vessels for Messrs. Retnymnis & Kulukundis. The engines, of the triple-expansion type, will be built by the North-Eastern Marine Engineering Company, Limited, Wallsend.

CHARLES CONNELL & COMPANY, LIMITED, Scotstoun, Glasgow, are to build a 9,000-ton cargo steamer for T. & J. Harrison, Limited, Liverpool. The propelling machinery, consisting of triple-expansion engines, will be supplied by Barclay, Curle & Company, Limited.

A REPORT OF THE Industries Committee of the Jarrow Town Council states that the Consett Iron Company, Limited, has been considering the possibility of making iron and steel at Jarrow. The Town Council has decided to grant every assistance to the firm in its negotiations.

JOHN I. THORNEYCROFT & COMPANY, LIMITED, Glasgow, are to supply the forty Diesel engines for the lifeboats to be installed on the Cunard-White Star liner "No. 552," and also on a 35,000-ton Cunarder, which is being built at Birkenhead by Cammell, Laird & Company, Limited.

THE FALKIRK IRON COMPANY, LIMITED, and the Grahamston Iron Company, Limited, Falkirk, are granting a full day's holiday to their employees on Coronation Day. In addition they are presenting them with monetary gifts on the following scale:—Men of 21 and over, 10s.; youths between 18 and 21, 7s. 6d.; and boys under 18, 5s. Women of 21, 7s. 6d.; and those under 21, 5s.

THE STANTON IRONWORKS COMPANY, LIMITED, near Nottingham, in celebration of the Coronation, have placed in the hands of trustees, representing their 14,000 employees, a fund to be provided by annual instalments, which they guarantee will produce a revenue of not less than £350 per annum, to be devoted at the discretion of a committee representing their employees for purposes of general benevolence not covered by existing works relief funds.

THE AMERICAN DEPARTMENT OF JUSTICE has filed a suit for the dissolution of the Aluminium Company of America on the grounds that it has violated the anti-trust laws and fixed prices in an oppressive and unreasonable manner. The immediate ground for the Government's action was the announcement by the company in March that the price of virgin ingots would be raised. The Attorney-General asserted that this increase was unreasonable and arbitrary, since the company's earnings, he alleged, had risen from about £1,904,000 in 1935 to about £4,170,000 in 1936. The company is alleged to control entirely the market of virgin aluminium in America.

ROBERT STEPHENSON & COMPANY, LIMITED, state that they propose to purchase the locomotive department of Hawthorn Leslie & Company, Limited, Newcastle-upon-Tyne, and the business and goodwill as from January 1, 1937, for the sum of £40,260. The purchase price is to be satisfied by the allotment to Hawthorn Leslie of 161,040 shares in the capital of the company at 5s. each, while Hawthorn Leslie will subscribe in cash at par for 113,960 shares. If this agreement is carried out, Hawthorn Leslies will make an offer to the existing shareholders of the company to purchase a quarter of their shares at par value. The deal does not involve Hawthorn Leslies' boiler works.

## Contracts Open

**Leamington Spa.**—32 yds. of cast-iron pipes, for the Town Council. Mr. J. Sutcliffe, borough engineer, Town Hall. (Fee £2 2s., returnable.)

**Port Elizabeth,** May 13.—Spun iron pipes (4-in., 6-in. and 12-in. internal diams.), sluice valves, tees, tapers, bends, crosses and collars, for the Port Elizabeth Municipality. The Department of Overseas Trade. (Reference T.Y. 31,312.)

**Rotherham,** May 10.—683 yds. of 6-in., 250 yds. of 4-in. and 134 yds. of 2-in. dia. cast-iron spigot and socket pipes and special castings manufactured in accordance with B.S.S. No. 78, 1917, for Class D pipes, for the Rural District Council. Mr. A. E. Lant, engineer, Grove Road, Moorgate, Rotherham. (Fee £2 2s., returnable.)

**Wallasey,** May 10.—Castings, phosphor bronze, iron and gunmetal, for the Town Council. The Ferries General Manager, Seacombe Ferry.

## Company Reports

**Robert Stephenson & Company, Limited.**—Loss for year of £20,200.

**Park Gate Iron & Steel Company, Limited.**—Dividend of 3½ per cent. for the year ended March 31, 1937.

**Glenfield & Kennedy, Limited.**—Final dividend of 5 per cent. on the ordinary shares, making 10 per cent. for the year ended March 31, plus a bonus of 5 per cent.

**Richardsons, Westgarth & Company, Limited.**—Trading loss for year ended December 31, 1936, £26,909; bank interest, £6,468; interest on 4½ per cent. debenture stock, £1,152; debit balance brought in, £26,551; debit carried forward, £62,330. Meeting, May 6.

**Manganese Bronze & Brass Company, Limited.**—Profit for 1936, £74,227; brought in, £1,732; debenture interest, £6,090; debenture redemption, £5,179; reserve for depreciation, £9,275; bad debt reserve, £1,300; investment reserve, £700; reserve for income tax, £4,000; final dividend of 10 per cent.; carried forward, £22,633.

**J. Stone & Company, Limited.**—Trading profit for 1936, after providing for income tax, £281,264; replacement, etc., of buildings, £2,940; depreciation of buildings, £2,158; depreciation of plant, etc., £73,154; net profit, £198,312; brought in, £125,660; preference dividend, £39,000; ordinary dividend of 20 per cent., £120,080; carried forward, £165,392.

**Hopkinsons, Limited.**—Profit for year ended January 31, 1937, after depreciation, £103,242; brought in, £15,309; preference dividend for the year and an interim dividend of 2½ per cent. on the ordinary shares, £25,353; provision for income tax, £26,000; to general reserve, £30,000; final dividend on the ordinary shares of 7½ per cent., £19,687; carried forward, £17,511.

## Personal

MR. ALAN SHERLOW has left the board of Federated Foundries, Limited.

DR. G. C. WATERHOUSE has been appointed a director of the Dominion Steel & Coal Corporation, Limited.

MR. ARTHUR DORMAN, director of Dorman, Long & Company, Limited, Middlesbrough, has been elected President of the Tees-side Chamber of Commerce.

MR. JAMES HOWIE, chief draughtsman of Glenfield & Kennedy, Limited, who has completed fifty years' service with the firm, has been presented by his colleagues with a writing bureau and a cabinet of cutlery for Mrs. Howie. He also received the "Glenfield Order of Merit."

LT.-COL. (WING-COMMANDER) A. S. W. DORE, general sales manager of Baldwins, Limited, and a director of Robt. B. Byass & Company, Limited, has recently been appointed a Deputy-Lieutenant for the County of Middlesex and elected vice-chairman of the Middlesex Territorial and Air Force Association.

MR. C. F. LUCAS, chairman of Edgar Allen & Company (South Africa), Limited, Johannesburg, is shortly coming to England on leave, and Mr. G. N. Nicholson, a southern representative of the firm, is leaving England during April to act as a salesman during the period of his absence. Mr. Nicholson expects to return to this country about the end of the year.

## Obituary

MR. BENJAMIN JACOBS, the inventor of the Petter oil engine, died at his home at Yeovil, on Tuesday. He had been associated with Petters, Limited for 60 years.

MR. THOMAS V. MCNIDDER died last month, at the age of 58 years. He was a local director of Hadfields, Limited, of Sheffield, and was formerly commercial manager of Industrial Steels, Limited, Sheffield.

## New Companies

*(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)*

**John Booth (Preston), Limited,** Phœnix Foundry, Derby Street, Preston.—Capital, £15,000. Ironfounders.—Directors: J. Benson and T. Yates.

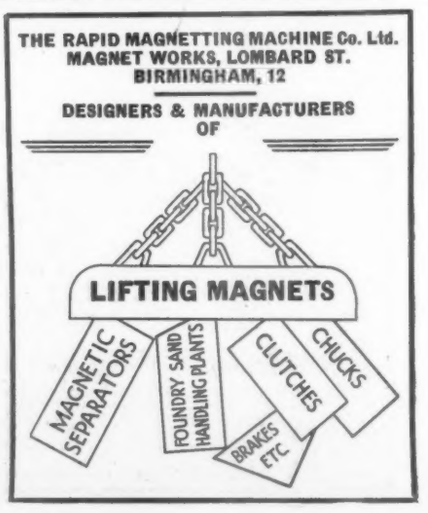
**British Light Metal Company, Limited.**—Capital, £2,000. Manufacturers and smelters of magnesium and other metals, etc. Subscriber: P. V. Rutledge, 11, Queen Victoria Street, London, E.C.4.

## Forthcoming Event

**Institute of British Foundrymen**

JUNE 8 TO 11.

Thirty-fourth Annual Conference in Derby.

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# Raw Material Markets

In accordance with general expectations, the prices of the main steel products were advanced as from May 1 and will be maintained at the new levels until December 31, 1937. For plates and sections the increase is £1 17s. 6d. Hematite is £1 5s. per ton higher, while basic iron has been raised by 17s. 6d. This is the first revision in steel prices since May of last year, while before that no changes had been made for seven years. Export prices to Empire markets of certain materials have also been increased. Producers continue to experience exceptional difficulty in complying with their contract commitments and full outputs are immediately taken up.

## Pig-Iron

**MIDDLESBROUGH.**—Parcels of French foundry iron continue to arrive in this area and the supplies are welcomed to supplement contract deliveries, though only small tonnages are involved. Consumers generally are handicapped by the lack of iron and would readily pay higher prices if it were possible to obtain increased supplies. No change has been announced with regard to pig-iron quotations, but it is expected that the prices, when revised, will show advances of about 20s. per ton.

Prices of hematite are based on No. 1 grade, which is now quoted at 123s. per ton for delivery on the North-East Coast, less 5s. rebate. It is anticipated that the publication of the new quotations will have the effect of facilitating the transaction of further business. Meanwhile, consumers continue to press for all the material that they can procure.

**LANCASHIRE.**—Specifications in this area are heavy and makers are despatching all available material in fulfilment of contract commitments. Textile-machinery makers, light-castings establishments, machine-tool and heavy electrical engineers, jobbing foundries and mining equipment makers are all fully employed. Derbyshire and Staffordshire brands of No. 3 foundry iron are quoted on the basis of 89s. per ton, with Northamptonshire iron at 87s. 6d., and Derbyshire forge iron at from 84s. to 86s., according to the class of user. Scottish foundry iron is still quoted at 106s. 6d. for delivery in the Manchester district. West Coast hematite is now at 131s. and East Coast at 130s. 6d., both subject to a rebate of 5s. per ton.

**MIDLANDS.**—Consumers of pig-iron continue to voice complaints that they are unable to obtain sufficient supplies to enable them to maintain their operations to capacity. Derbyshire furnaces in particular are well sold, having disposed of their outputs up to the end of September. Northamptonshire furnaces are generally only committed as far as July, being unwilling to sell further ahead. Stocks are negligible, and makers have to rely solely on their current production to meet the heavy demand. The prices for ordinary No. 3 foundry from the Midland furnaces are nominal at 83s. 6d. for Northants and 86s. for Derbyshire, Lincolnshire and North Staffordshire iron, including delivery to Birmingham and Black Country stations. The price of forge iron is unchanged at 5s. per ton below No. 3 foundry.

The supply of special irons continues to dwindle, and little new business can be considered. Up to £6 per ton is being paid for low-phosphorus iron. Refined iron is rather more plentiful, and the quotation varies from £7 5s. to £8 15s. The revised prices of hematite are £6 14s. 6d. for West Coast mixed numbers, £6 13s. 6d. for East Coast No. 3, and £6 13s. for Welsh mixed numbers.

**SCOTLAND.**—It is reported that some consumers of pig-iron have been forced to suspend operations temporarily, while others are working short time only. The official minimum price of No. 1 foundry remains at 90s. 6d. and No. 3 foundry is at 88s., f.o.t. furnaces. In some cases makers are demanding premiums on the foregoing figures. Business is stagnant in Cleveland iron, which is quoted at 84s. f.o.t. Falkirk and 87s. f.o.t. Glasgow. The steelworks continue to be very short of iron, but some relief is likely to be given when a steamer loaded with iron arrives from Baltimore. The official quotations of 123s. for mixed numbers of hematite and 107s. 6d. for basic iron (both less 5s. rebate) are now current.

## Coke

While a fair tonnage continues to change hands on the foundry-coke market, business has not been so heavy as it was before the revised price list came into operation. Many consumers are well covered for supplies. For delivery to Birmingham and district, the minimum price for best Durham coke is 46s. 6d. and Welsh coke ranges from 47s. 6d. to 57s. 6d. per ton.

## Steel

The volume of new business in steel is restricted by the difficulty the producers have in meeting the enormous demand, says the official report of the London Iron and Steel Exchange. In practically all departments of the market consumers are exercising pressure to obtain supplies, and in the majority of cases the manufacturers are only able to accept orders for urgently required material. The recent advance in prices closely followed the expectations of the market, and has had little influence upon the situation. For the time being users appear to be more interested in deliveries than in prices. In the semi-finished steel market, the situation has improved of late, and, although consumers are finding it difficult to obtain their full needs, operations appear to be less interrupted through lack of supplies than a short time ago. Imports of Continental material continue, but there are still heavy arrears of deliveries against the quota. The pressure on the part of the consuming works to obtain supplies of finished steel is unrelaxed. New business is difficult to arrange, and most of the manufacturers have sufficient work on their books to keep them employed for months.

## Scrap

There is little change to report in the scrap market, as the control scheme is not yet working satisfactorily; in fact, the publication of the stabilised prices for certain areas is still awaited. Supplies, also, are difficult to obtain, quite apart from the question of prices. As a result, business is confined to small parcels for early delivery. In the Cleveland area, prices are rising and machinery cast-iron scrap is quoted at a minimum of 87s. 6d. per ton, while good heavy foundry metal has advanced to 85s. From the Midlands it is reported that the demand is still considerably in excess of supply. The shortage of cast scrap, particularly, is causing much concern. There is a good turnover in Scotland at firm prices. All available supplies are eagerly taken up as soon as they come on the market.

## Metals

**Copper.**—Quiet conditions have prevailed in this market and there appears to be every likelihood of a continuance of dull trading for some time to come, as consumers generally are well covered. In the United States, business has been slow to materialise. The Customs smelters have taken the initiative in selling copper at 14 cents per lb., but others have not yet followed suit.

Metal Exchange quotations were as follow :—

*Cash.*—Thursday, £57 to £57 5s.; Friday, £58 10s. to £58 15s.; Monday, £59 5s. to £59 10s.; Tuesday, £60 5s. to £60 15s.; Wednesday, £59 10s. to £59 15s.

*Three Months.*—Thursday, £54 5s. to £54 7s. 6d.; Friday, £56 to £56 2s. 6d.; Monday, £57 10s. to £57 12s. 6d.; Tuesday, £57 17s. 6d. to £58; Wednesday, £56 12s. 6d. to £56 15s.

**Tin.**—According to the monthly tin statistics compiled by Mr. W. H. Gartsen (Henry Rogers, Sons & Company) the total visible supply on April 30, 1937, was 19,642 tons, against 19,596 tons on March 31, and 12,415 tons at the end of April, 1936. The carry-over in the Straits Settlements was 2,736 tons at the end of April, against 2,608 on March 31, and 812 at the end of April of last year, while the respective figures of the carry-over at the Arnhem (Holland) smelter were 1,435, 1,272 and 813 tons. Uncertainty has again been the keynote of the tin market during the past week and liquidation has been a prominent feature. The weekly market report issued by Brandeis, Goldschmidt & Company, Limited, states that "the downward trend of this metal has continued in spite of momentary signs of recovery. Lack of buying interest, principally in America, and continued free selling in the East, have created an unfavourable atmosphere in London, and, in the absence of support, prices have reacted sharply. In view of the unsatisfactory position, action on the part of producers is expected shortly, and an announcement of a cut in the production quotas at the next meeting of the producers would occasion no surprise. Whether such an action would be justified, however, is a matter of opinion."

Official quotations were as follow :—

*Cash.*—Thursday, £242 15s. to £243; Friday, £245 10s. to £246 10s.; Monday, £255 to £255 10s.; Tuesday, £252 to £252 10s.; Wednesday, £249 to £249 10s.

*Three Months.*—Thursday, £239 15s. to £240; Friday, £242 10s. to £242 15s.; Monday, £252 to £252 10s.; Tuesday, £249 to £249 10s.; Wednesday, £247 to £247 5s.

**Spelter.** — This market has been featureless and quiet conditions have prevailed. It is reported that supplies are now coming through in greater volume. Conditions in the United States, also, are dull and the price is understood to have been reduced to 6.66½ cents. Smelters are heavily committed.

Daily market prices :—

*Ordinary.*—Thursday, £22 3s. 9d.; Friday, £22 16s. 3d.; Monday, £23 16s. 3d.; Tuesday, £23 17s. 6d.; Wednesday, £23.

**Lead.**—In common with other base metals, the tone of this market has been dull during the past week. Consumption is well maintained, but consumers are displaying little interest at the present time. Business has been on a moderate scale in the United States and a fair tonnage has changed hands at 6 cents per lb., delivered New York.

Day-to-day quotations :—

*Soft Foreign (Prompt).*—Thursday, £22 8s. 9d.; Friday, £23 7s. 6d.; Monday, £24 12s. 6d.; Tuesday, £24 10s.; Wednesday, £23 17s. 6d.

## Applications for Trade Marks

*The following list of applications to register trade marks has been taken from the "Trade Marks Journal" :—*

"STURTEVANT."—Fans, pneumatic despatch tube plant, etc. Sturtevant Engineering Company, Limited, 147, Queen Victoria Street, London, E.C.4

"ALOTECTIC" AND "SILOTECTIC." — Metals. British Oxygen Company, Limited, Thames House, Millbank, London, S.W.1.

"SATCO."—Metals. Hoyt Metal Company of Great Britain, Limited, 105, Deodar Road, Putney, London, S.W.15.

"RHINO."—Ingot tin. Sale Tilney & Company, Limited, 3, Lloyd's Avenue, London, E.C.3.

"HIDUMINIUM R.R."—Metals. High Duty Alloys, Limited, 89, Buckingham Avenue, Trading Estate, Slough, Buckinghamshire.

"CAPIL."—Metal pipes. Associated Builders Merchants, Limited, Peter's Hill, Upper Thames Street, London, E.C.4.

"MAGOG" (DEVICE).—Metals. Baxter, Fell & Company, 36, Leadenhall Street, London, E.C.3.

## A Résumé of Some Studies on Sheet Steel Ground Coat Enamels

(*Concluded from page* 375.)

without any metallic oxides in the ground coat, and it was still used for some signs. It could, however, only be bent one way, and could not be formed, like steel, both ways. It had a naturally roughened surface, as shown under the microscope, with perfect enamelling results.

A question was asked whether "Armco" iron promoted dendritic growth more than ordinary iron, and MR. EDWARDS said he thought it did.

Mr. Stone was asked whether the economic position of "Armco" iron and that of steel had any direct association with the dendritic growth. He thought that a pure iron tended to form this growth, but the economic aspect had to be considered.

For **"easy stripping"** use

# YORKSHIRE SAND

**Yorkshire Sand is of a synthetic nature, its production being under careful laboratory control. Perfect standardization is obtained with the various grades, suitable for light and the heaviest steel castings.**

**It is because of the refractoriness of the sand and of the toughness of the mould surface that castings made with Yorkshire Sand are distinguishable by their excellent finish.**

*Please address all enquiries to the nearest Sales Office :*

## GENERAL REFRACTORIES LTD.,

**Genefax House, Sheffield**

*Telephone :* *Sheffield 31113 (6 lines).*

*Telegrams :* *"Genefax, Sheffield."*

**LONDON OFFICE: Russell House, Adelphi, W.C.2.**
**Telephone: Temple Bar 7361. Telegrams: "Genefax, Rand-London." Mr. A. C. Turner.**

**SCOTTISH OFFICE:** 48, West Regent Street, Glasgow. Telephone: 3009. Telegrams: "Genefax, Glasgow." (Mr. C. A. G. Thomson.)

**MANCHESTER OFFICE:** 9, Albert Square, Manchester, 2. Telephone: Blackfriars 6130. Telegrams: "Genefax, Manchester." (Mr. S. G. Throssell.)

**SWANSEA OFFICE:** Metropole Chambers, Wind Street, Swansea. Telephone: 3680. Telegrams: "Genefax, Swansea." (Mr. D. Hood-Williams.)

**CARDIFF OFFICE:** 17, Windsor Place, Cardiff. Telephone: 5796. Telegrams: "Genefax, Cardiff." (Mr. F. E. Rutter.)

**MIDDLESBROUGH OFFICE: Halifax Buildings, Exchange Place.**
**Telephone: Middlesbrough 3313. Telegrams: "Genefax, Middlesbrough."**

★

Read what an IMPORTANT STEELFOUNDER says :—

"During the 40 years I have been connected with Steel Foundry work, considerable changes have taken place. Away back, we had Steel Moulders' Composition, Old Crucible Pots, etc., and each works claimed to have its own 'secret' moulding composition. High Silica Sand has eliminated practically all these from many foundries and to-day we have your 'Yorkshire Sand' which acts almost like a chill, and leaves the skin of the casting blue-black and as clean as cast iron.

The hot steel lies quietly against the wall of sand, and often when the casting has been lifted out of the mould, the latter looks as if it could be used over again, just like a permanent mould."

# RAW MATERIALS—PRICE LIST

(Wednesday, May 5, 1937)

## COPPER

| | £ | s. | d. |
|---|---|---|---|
| Standard cash | 59 | 10 | 0 |
| Three months | 56 | 12 | 6 |
| Electrolytic | 63 | 0 | 0 |
| Tough | 63 | 0 | 0 |
| Best selected | 63 | 10 | 0 |
| Sheets | 92 | 5 | 0 |
| India | 76 | 15 | 0 |
| Wire bars | 64 | 15 | 0 |
| Ingot bars | 64 | 15 | 0 |
| H.C. wire rods | 68 | 5 | 0 |
| Off. av. cash, Apr. | 62 | 12 | $1\frac{10}{11}$ |
| Do., 3 mths., Apr. | 60 | 18 | $6\frac{2}{11}$ |
| Do., Sttlmnt., Apr. | 62 | 11 | $8\frac{6}{11}$ |
| Do., Electro, Apr. | 67 | 10 | $8\frac{2}{11}$ |
| Do., B.S., Apr. | 67 | 14 | 2 |
| Do., wire bars, Apr. | 68 | 9 | $1\frac{1}{11}$ |

Solid drawn tubes 14d.
Brazed tubes 14d.
Wire 10½d.

## BRASS

Solid drawn tubes 12½d.
Brazed tubes 14½d.
Rods, drawn 10¾d.
Rods, extd. or rlld. 7½d.
Sheets to 10 w.g. 10½d.
Wire 10d.
Rolled metal 9¾d.
Yellow metal rods 7¾d.

## TIN

| | £ | s. | d. |
|---|---|---|---|
| Standard cash | 249 | 0 | 0 |
| Three months | 247 | 0 | 0 |
| English | 249 | 5 | 0 |
| Bars | 251 | 10 | 0 |
| Straits | 250 | 5 | 0 |
| Eastern | 252 | 10 | 0 |
| Banca (nom.) | 250 | 10 | 0 |
| Off. av. cash, Apr. | 267 | 8 | $7\frac{7}{11}$ |
| Do., 3 mths., Apr. | 264 | 4 | $10\frac{7}{11}$ |
| Do., Sttlmt., Apr. | 267 | 7 | $11\frac{5}{11}$ |

## SPELTER

| | £ | s. | d. |
|---|---|---|---|
| Ordinary | 23 | 0 | 0 |
| Remelted | 21 | 2 | 6 |
| Hard | 20 | 2 | 6 |
| Electro 99.9 | 25 | 12 | 6 |
| English | 24 | 15 | 0 |
| India | 20 | 0 | 0 |
| Zinc dust | 25 | 0 | 0 |
| Zinc ashes | 9 | 5 | 0 |
| Off. aver., Apr. | 26 | 5 | $7\frac{7}{44}$ |
| Aver. spot, Apr. | 26 | 4 | $3\frac{9}{11}$ |

## LEAD

| | £ | s. | d. |
|---|---|---|---|
| Soft foreign, ppt. | 23 | 17 | 6 |
| Empire (nom.) | 25 | 5 | 0 |
| English | 26 | 0 | 0 |
| Off. aver., Apr. | 25 | 18 | $11\frac{1}{22}$ |
| Aver. spot, Apr. | 26 | 0 | $3\frac{9}{22}$ |

## ALUMINIUM

Ingots £100 to £105
Wire 1/3 to 1/4 lb.
Sheet and foil 1/2 to 1/4 lb.

## ZINC SHEETS, &c.

Zinc sheets, English 36 10 0 to 37 0 0
Do., V.M. ex-whse. 36 10 0 to 37 0 0
Rods 33 0 0

## ANTIMONY

English 85 0 0 to 86 0 0
Chinese, ex-whse. 74 0 0
Crude, c.i.f. 41 0 0

## QUICKSILVER

Quicksilver 13 17 0

## FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—
25% 12 0 0 (nom.)
45/50% 10 15 0 to 12 0 0 (nom.)
75% 15 15 0 to 17 0 0 (nom.)
Ferro-vanadium—
35/50% 12/8 lb. Va
Ferro-molybdenum—
70/75% carbon-free 4/9 lb. Mo.
Ferro-titanium—
20/25% carbon-free 9d. lb.
Ferro-phosphorus, 20/25% £21 to £22
Ferro-tungsten—
80/85% 5/– lb. (nom.)
Tungsten metal powder—
98/99% 5/3 lb. (nom.)
Ferro-chrome—
2/4% car. 32 17 6
4/6% car. 22 10 0
6/8% car. 21 10 0
8/10% car. 21 10 0
Ferro-chrome—
Max. 2% car. 32 10 0
Max. 1% car. 35 15 0
Max. 0.5% car. 36 10 0
70% carbon-free 9½d. lb.
Nickel—99.5/100% £180 to £185
"F" nickel shot £165 0 0
Ferro-cobalt, 98/99% 7/3 lb.
Metallic chromium—
96/98% 2/5 lb.
Ferro-manganese—
76/80% loose £16 15 0 to 17 5 0
76/80% packed £17 15 0 to 18 5 0
76/80% export £20 0 0
Metallic manganese—
94/96% carbon-free 1/3 lb.
Per ton unless otherwise stated, basis 2-ton lots.

## HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten 2s. 7d.
Finished bars, 18% tungsten 3s. 6d.
Per lb. net, d/d buyers' works.
Extras—
Rounds and squares, 3 in. and over 4d. lb.
Rounds and squares, under ½ in. to ¼ in. 3d. lb.
Do., under ¼ in. to $\frac{3}{16}$ in. 1/– lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in. 3d. lb.
Do., under ½ in. × ¼ in. 1/– lb.
Bevels of approved sizes and sections 6d. lb.
Bars cut to length, 10% extra.

## SCRAP

| South Wales— | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Heavy steel | 3 | 8 | 0 to | 3 | 10 | 0 |
| Mixed iron and steel | 3 | 5 | 0 to | 3 | 7 | 6 |
| Heavy cast iron | 3 | 8 | 0 to | 3 | 10 | 0 |
| Good machinery | 3 | 15 | 0 to | 4 | 0 | 0 |

| Cleveland— | £ | s. | d. |
|---|---|---|---|
| Heavy steel | 3 | 7 | 0 |
| Steel turnings | 2 | 12 | 6 |
| Heavy cast iron | 4 | 5 | 0 |
| Heavy machinery | 4 | 7 | 6 |

| Midlands— | £ | s. | d. |
|---|---|---|---|
| Short heavy steel | 3 | 15 | 0 |
| Light cast-iron scrap | 3 | 10 | 0 |
| Heavy wrought iron | 3 | 17 | 6 to 4 2 6 |
| Steel turnings | 2 | 2 | 6 to 2 5 0 |

| Scotland— | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Heavy steel | 3 | 4 | 6 to | 3 | 7 | 0 |
| Ordinary cast iron | 4 | 7 | 6 to | 4 | 10 | 0 |
| Cast-iron borings | 2 | 0 | 0 to | 2 | 2 | 6 |
| Wrot-iron piling | 4 | 2 | 6 to | 4 | 5 | 0 |
| Heavy machinery | 4 | 12 | 6 | | | |

London—Merchants' buying prices, delivered yard.

| | £ | s. | d. |
|---|---|---|---|
| Copper (clean) | 48 | 0 | 0 |
| Brass | 31 | 0 | 0 |
| Lead (less usual draft) | 20 | 0 | 0 |
| Tea lead | 15 | 0 | 0 |
| Zinc | 15 | 0 | 0 |
| New aluminium cuttings | 74 | 0 | 0 |
| Braziery copper | 43 | 0 | 0 |
| Gunmetal | 45 | 0 | 0 |
| Hollow pewter | 160 | 0 | 0 |
| Shaped black pewter | 115 | 0 | 0 |

## PIG-IRON

N.E. Coast (d/d Tees-side area)—
Foundry No. 1 83/6
,, No. 3 81/–
,, No. 4 80/–
Forge No. 4 80/–
Hematite No. 1 123/–*
Hematite M/Nos. 122/6*

N.W. Coast—
Hem. M/Nos. d/d Glas. 123/–*
,, d/d Birm. 134/6*
Malleable iron d/d Birm. —

Midlands (d/d Birmingham dist.)—
Staffs No. 4 forge 83/–
,, No. 3 fdry. 86/–
Northants forge 80/6
,, fdry. No. 3 83/6
,, fdry. No. 1 86/6
Derbyshire forge 83/–
,, fdry. No. 3 86/–
,, fdry. No. 1 89/–

Scotland—
Foundry, No. 1, f.o.t. 90/6
,, No. 3, f.o.t. 88/–
Cleveland No. 3, Glasgow 87/–
,, ,, Falkirk 84/–
Scottish hem. M/Nos. d/d 123/–*

Sheffield (d/d district)—
Derby forge 80/6
,, fdry. No. 3 83/6
Lincs forge 80/6
,, fdry. No. 3 83/6
W.C. hematite 128/6*

Lancashire (d/d eq. Man.)—
Derby fdry. No. 3 89/–
Staffs fdry. No. 3 89/–
Northants fdry. No. 3 87/6
Cleveland fdry. No. 3 89/–
Glengarnock, No. 3 106/6
Clyde, No. 3 106/6
Monkland, No. 3 106/6
Summerlee, No. 3 106/6
Eglinton, No. 3 106/6
Gartsherrie, No. 3 106/6
Shotts, No. 3 106/6

* Subject to a rebate of 5s. per ton under certain conditions.

## FINISHED IRON AND STEEL

*Usual district deliveries for iron; delivered consumer's station for steel.*

| Iron— | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Bars (cr.) | 11 | 17 | 6 | | | |
| Nut and bolt iron | 10 | 5 | 0 to | 10 | 15 | 0 |
| Hoops | 12 | 15 | 0 | | | |
| Marked bars (Staffs) f.o.t. | 14 | 7 | 6 | | | |
| Gas strip | 12 | 15 | 0 | | | |
| Bolts and nuts, ¾ in. × 4 in. | 17 | 10 | 0 and up. | | | |

| Steel— | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Plates, ship, etc. | 11 | 8 | 0 to | 11 | 10 | 6 |
| Boiler plts | 11 | 18 | 0 to | 12 | 0 | 6 |
| Chequer plts. | 13 | 0 | 6 | | | |
| Angles | 11 | 0 | 6 | | | |
| Tees | 12 | 0 | 6 | | | |
| Joists | 11 | 0 | 6 | | | |
| Rounds and squares, 3 in. to 5½ in. | 12 | 0 | 6 | | | |
| Rounds under 3 in. to ⅛ in. (Untested) | 11 | 9 | 0 | | | |
| Flats—8 in. wide and over | 11 | 5 | 6 | | | |
| ,, under 8 in. and over 5 in. | 11 | 10 | 6 | | | |
| Rails, heavy | 10 | 2 | 6 | | | |
| Fishplates | 14 | 2 | 6 | | | |
| Hoops (Staffs) | 12 | 4 | 0 | | | |
| Black sheets, 24g. (4-t. lots) | 15 | 15 | 0 | | | |
| Galv. cor. shts. ( ,, ) | 19 | 10 | 0 | | | |
| Galv. flat shts. ( ,, ) | 20 | 0 | 0 | | | |
| Galv. fencing wire, 8g. plain | 17 | 10 | 0 | | | |
| Billets, soft, 100-ton lots | 7 | 17 | 6 | | | |
| Sheet bars | 7 | 15 | 0 | | | |
| Tin bars | 7 | 15 | 0 | | | |

## PHOSPHOR BRONZE

| | Per lb. basis |
|---|---|
| Strip | 13d. |
| Sheet to 10 w.g. | 14d. |
| Wire | 15d. |
| Rods | 15d. |
| Tubes | 20d. |
| Castings | 16d. |

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

## NICKEL SILVER, &c.

| | Per lb. |
|---|---|
| Ingots for raising | 9d. to 1/3 |
| Rolled— | |
| To 9 in. wide | 1/3 to 1/9 |
| To 12 in. wide | 1/3½ to 1/9½ |
| To 15 in. wide | 1/3½ to 1/9½ |
| To 18 in. wide | 1/4 to 1/10 |
| To 21 in. wide | 1/4½ to 1/10½ |
| To 25 in. wide | 1/5 to 1/11 |
| Ingots for spoons and forks | 9d. to 1/5½ |
| Ingots rolled to spoon size | 1/– to 1/8½ |
| Wire round— | |
| to 10g. | 1/6½ to 2/1½ |

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/5½ upwards.

## AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

| | Dols. |
|---|---|
| No. 2 foundry, Phila. | 25.76 |
| No. 2 foundry, Valley | 24.00 |
| No. 2 foundry, Birm. | 20.38 |
| Basic, Valley | 23.50 |
| Malleable, Valley | 24.00 |
| Grey forge, Valley | 23.50 |
| Ferro-mang. 80%, seaboard | 95.00 |
| O.-h. rails, h'y, at mill | 42.50 |
| Billets | 37.00 |
| Sheet bars | 37.00 |
| Wire rods | 47.00 |
| | Cents. |
| Iron bars, Chicago | 2·40 |
| Steel bars | 2.45 |
| Tank plates | 2.25 |
| Beams, etc. | 2.15 |
| Skelp, grooved steel | 2.10 |
| Steel hoops | 2.40 |
| Sheets, black, No. 24 | 2.40 |
| Sheets, galv., No. 24 | 3.80 |
| Wire nails | 2.75 |
| Plain wire | 2.90 |
| Barbed wire, galv. | 3.40 |
| Tinplates, 100-lb box | $5.35 |

## COKE (at ovens)

| | |
|---|---|
| Welsh foundry | 32/6 to 33/– |
| ,, furnace | 27/– to 28/– |
| Durham foundry | 34/6 |
| ,, furnace | 32/6 |
| Scotland foundry | — |
| ,, furnace | 28/– |

## TINPLATES

f.o.b. Bristol Channel ports.

| | | |
|---|---|---|
| I.C. cokes | 20×14 per box | 24/6 to 25/6 |
| ,, | 28×20 ,, | 49/– to 51/– |
| ,, | 20×10 ,, | 34/6 to 35/6 |
| ,, | 18¾×14 ,, | 24/9 to 25/9 |
| C.W. | 20×14 ,, | 22/– to 23/– |
| ,, | 28×20 ,, | 44/– to 46/– |
| ,, | 20×10 ,, | 31/– to 32/6 |
| ,, | 18¾×14 ,, | 23/– to 25/– |

## SWEDISH CHARCOAL IRON & STEEL

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Pig-iron | 12 | 0 | 0 to | 13 | 0 | 0 |
| Bars-hammered, basis | 20 | 0 | 0 to | 21 | 0 | 0 |
| Bars and nail-rods, rolled, basis | 19 | 0 | 0 to | 20 | 0 | 0 |
| Blooms | 16 | 0 | 0 to | 17 | 0 | 0 |
| Keg steel | 27 | 0 | 0 to | 30 | 0 | 0 |
| Faggot steel | 20 | 0 | 0 to | 25 | 0 | 0 |
| Bars and rods dead soft, st' | 19 | 0 | 0 to | 20 | 0 | 0 |

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

## DAILY FLUCTUATIONS

### Standard Copper (cash)

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Apr. | 29 .. | 57 | 0 | 0 | dec. | 70/- |
| ,, | 30 .. | 58 | 10 | 0 | inc. | 30/- |
| May | 3 .. | 59 | 5 | 0 | ,, | 15/- |
| ,, | 4 .. | 60 | 5 | 0 | ,, | 20/- |
| ,, | 5 .. | 59 | 10 | 0 | dec. | 15/- |

### Electrolytic Copper

| | | £ | s. | d | | |
|---|---|---|---|---|---|---|
| Apr. | 29 .. | 60 | 10 | 0 | dec. | 40/- |
| ,, | 30 .. | 62 | 0 | 0 | inc. | 30/- |
| May | 3 .. | 63 | 0 | 0 | ,, | 20/- |
| ,, | 4 .. | 63 | 10 | 0 | ,, | 10/- |
| ,, | 5 .. | 63 | 0 | 0 | dec. | 10/- |

### Standard Tin (cash)

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Apr. | 29 .. | 242 | 15 | 0 | dec. | 265/- |
| ,, | 30 .. | 245 | 10 | 0 | inc. | 55/- |
| May | 3 .. | 255 | 0 | 0 | ,, | 190/- |
| ,, | 4 .. | 252 | 0 | 0 | dec. | 60/- |
| ,, | 5 .. | 249 | 0 | 0 | ,, | 60/- |

### Tin (English ingots)

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Apr. | 29 .. | 243 | 0 | 0 | dec. | 260/- |
| ,, | 30 .. | 246 | 0 | 0 | inc. | 60/- |
| May | 3 .. | 255 | 0 | 0 | ,, | 180/- |
| ,, | 4 .. | 252 | 10 | 0 | dec. | 50/- |
| ,, | 5 .. | 249 | 5 | 0 | ,, | 65/- |

### Spelter (ordinary)

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Apr. | 29 .. | 22 | 3 | 9 | dec. | 46/3 |
| ,, | 30 .. | 22 | 16 | 3 | inc. | 12/6 |
| May | 3 .. | 23 | 16 | 3 | ,, | 20/- |
| ,, | 4 .. | 23 | 17 | 6 | ,, | 1/3 |
| ,, | 5 .. | 23 | 0 | 0 | dec. | 17/6 |

### Spelter (Electro, 99.9 per cent.)

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Apr. | 29 .. | 24 | 13 | 9 | dec. | 46/3 |
| ,, | 30 .. | 25 | 7 | 6 | inc. | 13/9 |
| May | 3 .. | 26 | 10 | 0 | ,, | 22/6 |
| ,, | 4 .. | 26 | 10 | 0 | No | change |
| ,, | 5 .. | 25 | 12 | 6 | dec. | 17/6 |

### Lead (soft foreign, prompt)

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Apr. | 29 .. | 22 | 8 | 9 | dec. | 52/6 |
| ,, | 30 .. | 23 | 7 | 6 | inc. | 18/9 |
| May | 3 .. | 24 | 12 | 6 | ,, | 25/- |
| ,, | 4 .. | 24 | 10 | 0 | dec. | 2/6 |
| ,, | 5 .. | 23 | 17 | 6 | ,, | 12/6 |

### Lead (English)

| | | £ | s. | d. | | |
|---|---|---|---|---|---|---|
| Apr. | 29 .. | 24 | 10 | 0 | dec. | 50/- |
| ,, | 30 .. | 25 | 5 | 0 | inc. | 15/- |
| May | 3 .. | 26 | 10 | 0 | ,, | 25/- |
| ,, | 4 .. | 26 | 10 | 0 | No | change |
| ,, | 5 .. | 26 | 0 | 0 | dec. | 10/- |

## AVERAGE MONTHLY PRICES OF MARKED BARS (SOUTH STAFFS).

| Year | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Yearly average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| 1903 .. .. | 8 5 0 | 8 5 0 | 8 5 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 8 9 |
| 1904 .. .. | 8 10 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 10 |
| 1905 .. .. | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 10 0 | 8 10 0 | 8 1 8 |
| 1906 .. .. | 8 10 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 9 0 0 | 8 15 16 |
| 1907 .. .. | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 |
| 1908 .. .. | 9 0 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 5 10 |
| 1909 .. .. | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 |
| 1910 .. .. | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 |
| 1911 .. .. | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 0 0 |
| 1912 .. .. | 8 10 0 | 8 10 0 | 8 10 0 | 8 15 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 8 0 | 9 10 0 | 9 10 0 | 9 10 0 | 9 15 0 | 9 1 6 |
| 1913 .. .. | 10 0 0 | 10 0 0 | 10 0 0 | 10 0 0 | 10 0 0 | 10 0 0 | 10 0 0 | 9 10 0 | 9 10 0 | 9 4 0 | 9 0 0 | 9 0 0 | 9 12 8 |
| 1914 .. .. | 8 12 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 8 10 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 8 14 4 |
| 1915 .. .. | 9 0 0 | 9 0 0 | 9 3 0 | 10 2 0 | 10 15 0 | 11 10 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 7 6 | 12 10 0 | 13 10 0 | 11 5 0 |
| 1916 .. .. | 13 10 0 | 13 10 0 | 14 13 0 | 15 0 0 | 15 0 0 | 15 0 0 | 15 0 0 | 15 10 0 | 15 10 0 | 15 0 0 | 15 10 0 | 15 0 0 | 14 16 7 |
| 1917 .. .. | 15 10 0 | 15 10 0 | 15 10 0 | 15 10 0 | 15 10 0 | 15 10 0 | 15 10 0 | 15 10 0 | 15 10 0 | 15 10 0 | 15 10 0 | 15 10 0 | 15 10 0 |
| 1918 .. .. | 15 12 6 | 16 0 0 | 16 0 0 | 16 0 0 | 16 0 0 | 16 0 0 | 16 0 0 | 16 0 0 | 16 0 0 | 17 0 0 | 17 0 0 | 17 0 0 | 16 6 3 |
| 1919 .. .. | 18 0 0 | 18 10 0 | 20 0 0 | 20 0 0 | 23 0 0 | 23 0 0 | 23 0 0 | 24 12 0 | 25 0 0 | 25 0 0 | 25 0 0 | 25 5 0 | 22 10 7 |
| 1920 .. .. | 26 17 6 | 27 0 0 | 28 0 0 | 30 5 0 | 30 10 0 | 33 10 0 | 33 10 0 | 33 10 0 | 33 10 0 | 33 10 0 | 33 10 0 | 33 10 0 | 31 10 2 |
| 1921 .. .. | 31 10 0 | 30 3 4 | 27 10 0 | 27 10 0 | 27 10 0 | 24 15 0 | 21 0 0 | 20 0 0 | 20 0 0 | 17 10 0 | 17 0 0 | 16 0 0 | 23 7 4 |
| 1922 .. .. | 16 0 0 | 14 17 6 | 14 10 0 | 13 10 0 | 13 10 0 | 13 10 0 | 13 10 0 | 13 10 0 | 13 10 0 | 13 10 0 | 13 10 0 | 13 10 0 | 13 18 1½ |
| 1923 .. .. | 13 10 0 | 13 10 0 | 13 16 0 | 14 7 6 | 14 10 0 | 14 10 0 | 14 10 0 | 14 10 0 | 14 10 0 | 14 10 0 | 14 10 0 | 14 10 0 | 14 5 3½ |
| 1924 .. .. | 14 10 0 | 14 10 0 | 14 10 0 | 15 0 0 | 15 0 0 | 15 0 0 | 15 0 0 | 15 0 0 | 15 0 0 | 15 0 0 | 15 0 0 | 14 17 6 | 14 17 3½ |
| 1925 .. .. | 15 0 0 | 15 0 0 | 15 0 0 | 15 0 0 | 15 0 0 | 14 10 0 | 14 10 0 | 14 10 0 | 14 10 0 | 14 10 0 | 14 10 0 | 14 0 0 | 14 13 4 |
| 1926 .. .. | 14 0 0 | 14 0 0 | 14 0 0 | 14 0 0 | 14 0 0 | 14 0 0 | 14 0 0 | 14 0 0 | 14 0 0 | 14 0 0 | * | 14 10 0 | 14 0 10 |
| 1927 .. .. | 14 10 0 | 14 10 0 | 14 10 0 | 14 10 0 | 14 10 0 | 13 10 0 | 13 10 0 | 13 10 0 | 13 10 0 | 13 0 0 | 13 0 0 | 12 18 0 | 13 15 8 |
| 1928 .. .. | 12 10 0 | 12 10 0 | 12 10 0 | 12 2 6 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 2 8½ |
| 1929 .. .. | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 7 6 | 12 10 0 | 12 10 0 | 12 2 3½ |
| 1930 .. .. | 12 10 0 | 12 10 0 | 12 10 0 | 12 10 0 | 12 10 0 | 12 10 0 | 12 10 0 | 12 10 0 | 12 10 0 | 12 10 0 | 12 10 0 | 12 10 0 | 12 10 0 |
| 1931 .. .. | 12 10 0 | 12 10 0 | 12 10 0 | 12 8 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 3 2 |
| 1932 .. .. | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 |
| 1933 .. .. | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 |
| 1934 .. .. | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 |
| 1935 .. .. | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 | 12 0 0 |
| 1936 .. .. | 12 0 0 | 12 2 6 | 12 10 0 | 12 10 0 | 12 10 0 | 12 10 0 | 12 10 0 | 12 15 0 | 13 0 0 | 13 0 0 | 13 0 0 | 13 0 0 | 12 12 3½ |
| 1937 .. .. | 13 0 0 | 13 0 0 | 14 0 7½ | 14 7 6 | — | — | — | — | — | — | — | — | — |

* No quotation available.

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